Final

Parcel B Technical Memorandum in Support of a Record of Decision Amendment

Hunters Point Shipyard
San Francisco, California

December 12, 2007

Volume I of III
Text, Figures, and Tables

Prepared for:
Base Realignment and Closure
Program Management Office West
San Diego, California

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Prepared under:
Naval Facilities Engineering Command
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Contract Task Order 019

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Enclosure (1) is the Final Parcel B Technical Memorandum in Support of a Record of Decision Amendment.

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Enclosure: 1. Final Parcel B Technical Memorandum in Support of a Record of Decision Amendment, December 12, 2007

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DEPARTMENT OF THE NAVY

REVIEW AND APPROVAL

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ACRONYMS AND ABBREVIATIONS

§	Section
§§	Sections
µg/L	Microgram per liter
ARAR	Applicable or relevant and appropriate requirement
ARIC	Area requiring institutional controls
BAAQMD	San Francisco Bay Area Air Quality Management District
Basin Plan	Water Quality Control Plan for the San Francisco Bay Basin
BCT	Base Realignment and Closure Cleanup Team
BHC	Benzene hexachloride, also known as hexachlorocyclohexane
bgs	Below ground surface
BRAC	Base Realignment and Closure
BTEX	Benzene, toluene, ethylbenzene, and xylenes
Cal. Code Regs.	*California Code of Regulations*
CE2	CE2 Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
COC	Chemical of concern
COPC	Chemical of potential concern
CSM	Conceptual site model
CTR	California Toxics Rule
DNAPL	Dense nonaqueous-phase liquid
DoD	Department of Defense
DTSC	Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
ERRG	Engineering/Remediation Resources Group
ESD	Explanation of significant differences
FFA	Federal facility agreement
FRTR	Federal Remediation Technologies Roundtable
FS	Feasibility study
ft^2	Square feet
GRA	General response action
HGAL	Hunters Point groundwater ambient level
HHRA	Human health risk assessment

HI	Hazard index
HPAL	Hunters Point ambient level
HPS	Hunters Point Shipyard
IR	Installation Restoration
IT Corp.	IT Corporation
ITSI	Innovative Technical Solutions, Inc.
LFR	Levine-Fricke-Recon, Inc.
LUC RD	Land use control remedial design
MCL	Maximum contaminant level
mg/kg	Milligram per kilogram
MOA	Memorandum of agreement
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
O&M	Operation and maintenance
OSWER	Office of Solid Waste and Emergency Response
PCB	Polychlorinated biphenyl
POC	Point of compliance
PQL	Practical quantitation limit
PRC	PRC Environmental Management, Inc.
PRG	Preliminary remediation goal
RAMP	Remedial action monitoring program
RAO	Remedial action objective
RBC	Risk-based concentration
RCRA	Resource Conservation and Recovery Act
RD	Remedial design
RI	Remedial investigation
ROD	Record of decision
RU	Remedial unit
SARA	Superfund Amendments and Reauthorization Act
SI	Site inspection
SLERA	Screening-level ecological risk assessment
SMP	Soil management plan
SVE	Soil vapor extraction

Tetra Tech	Tetra Tech EM Inc.
tit.	Title
TMSRA	Technical memorandum in support of a record of decision amendment
URS	URS Corporation
U.S.C.	*United States Code*
VOC	Volatile organic compound
Water Board	San Francisco Bay Regional Water Quality Control Board
ZVI	Zero-valent iron

EXECUTIVE SUMMARY

The U.S. Department of Navy has prepared this technical memorandum in support of a record of decision (ROD) amendment (TMSRA) to address remaining contamination in soil and groundwater at Hunters Point Shipyard (HPS) Parcel B. Hunters Point Shipyard is a deactivated shipyard on San Francisco Bay in southeastern San Francisco, California. The overall purpose of this TMSRA is to provide information to support a future proposed plan and ROD amendment that will align the final remedy for Parcel B with its planned reuse and address the recommendations summarized in the first five-year review of remedial actions. This TMSRA focuses on activities the Navy has conducted since the ROD was signed in October 1997.

PURPOSE AND BACKGROUND OF TMSRA

Environmental activities at Parcel B were conducted under the Navy's Installation Restoration (IR) Program in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The typical sequence in the CERCLA remedial process includes a preliminary assessment and site inspection, remedial investigation, feasibility study, proposed plan, public comment period, ROD, remedial design (RD), remedial action, and post-construction reporting. Parcel B has completed the steps through post-construction reporting (including the five-year review); however, updated information about the site that became available during the remedial action indicates that modifications to selected soil and groundwater remedies should be considered to ensure long-term protectiveness. Updated information includes items such as:

- The ubiquitous nature of metals in soil across Parcel B
- The presence of methane and mercury
- The findings of a screening-level ecological risk assessment (SLERA)
- Changes in concentrations and toxicity criteria for volatile organic compounds (VOC) found in groundwater
- Findings from removal actions to address radiological contaminants.

The five-year review (Tetra Tech 2003d) concluded that the remedy selected in the ROD (Navy 1997) needs to be modified to be protective in the long term. The HPS Base Realignment and Closure (BRAC) Cleanup Team (BCT) has therefore extended the schedule of CERCLA activities (contained in the federal facility agreement [FFA]) to evaluate potential modifications to the Parcel B remedy and support the preparation of this TMSRA.

The Navy will propose a ROD amendment for Parcel B if the Navy determines that proposed changes to the selected remedy based on the evaluations in the TMSRA will "fundamentally alter the basic features of the selected remedy with respect to scope, performance, or cost" as described in the NCP at Title 40 *Code of Federal Regulations* (CFR) Section 300.435(c)(2)(ii). For example, the consideration of parcel-wide covers to address soil contamination instead of excavation may represent a fundamental change in the scope of the remedy. For groundwater, addition of active groundwater treatment methodologies to the remedy may be a fundamental change in the scope.

The updated information mentioned above and the more comprehensive understanding of groundwater, together with the planned land use, indicate the need to revise the conceptual site model, evaluate additional remedial actions, and evaluate amending the ROD. This TMSRA provides the support for the decisions on remediation alternatives, in the same way that the feasibility study supported the initial proposed plan and ROD. The TMSRA provides a practical path forward to evaluate additional remedial actions that will support parcel transfer.

This report includes (1) a revised human health risk assessment (HHRA) that incorporates modified protocols and procedures for conducting HHRAs at Hunters Point Shipyard agreed to by the BCT, (2) a SLERA, (3) updated remedial action objectives that are consistent with the conveyance agreement between the United States and the San Francisco Redevelopment Agency, and (4) development and evaluation of revised remedial alternatives based on these updates. This report includes updated remedial alternatives and a reevaluation of remedial alternatives based on the new data, the revised HHRA, and the SLERA.

This executive summary discusses the background of Hunters Point Shipyard, the history and setting of Parcel B, previously conducted remediation activities, results of the revised HHRA and the SLERA, and the alternatives evaluation process for Parcel B.

HUNTERS POINT SHIPYARD BACKGROUND

Hunters Point Shipyard consists of 866 acres: 420 acres on land and 446 acres under water in San Francisco Bay. In 1940, the Navy obtained ownership of Hunters Point Shipyard for shipbuilding, repair, and maintenance. After World War II, activities at Hunters Point Shipyard shifted to submarine maintenance and repair. However, the Navy continued to operate carrier overhaul and ship maintenance and repair facilities through the 1960s. Other significant activities after World War II included decontamination of ships used during Operation Crossroads nuclear weapons tests; these activities occurred mainly in 1946 and 1947. Hunters Point Shipyard was also the site of the Naval Radiological Defense Laboratory from the late 1940s until 1969. Initial tasks for the laboratory included research into decontamination methods, personnel protection, and development of radiation detection instrumentation. Laboratory responsibilities grew to also include practical and applied research into the effects of radiation on living organisms and on natural and synthetic materials, in addition to continued decontamination experimentation. Hunters Point Shipyard was deactivated in 1974 and remained largely unused until 1976. Between 1976 and 1986, the Navy leased most of Hunters Point Shipyard to Triple A Machine Shop, Inc., a private ship repair company. The Navy resumed occupancy of Hunters Point Shipyard in 1987.

Because past shipyard operations left hazardous materials on site, Hunters Point Shipyard property was placed on the National Priorities List in 1989 as a Superfund site pursuant to CERCLA as amended by the Superfund Amendments and Reauthorization Act of 1986. In 1991, Hunters Point Shipyard was designated for closure under the Defense Base Closure and Realignment Act of 1990. Closure at Hunters Point Shipyard involves conducting environmental remediation and making the property available for nondefense use.

PARCEL B HISTORY AND SETTING

Parcel B is bounded by other portions of Hunters Point Shipyard, private property, and by San Francisco Bay. Most of Parcel B was formerly part of the industrial support area and was used for shipping, ship repair, training, barracks, and offices. According to the city's redevelopment plan, Parcel B will be zoned for the following reuses: research and development, mixed uses, educational and cultural, and open space.

Historically, Parcel B was investigated by IR site. Parcel B originally consisted of 16 IR sites, which were investigated during the remedial investigation, and two site inspection sites, which did not require further investigation. Since that time, the boundaries of Parcel B have been redefined and IR-06 and IR-25 have become part of Parcel C. Sites SI-45 (steam line system) and IR-50 (storm drain and sanitary sewer system) are facility-wide utility sites that traverse other sites. Site IR-51 is a facility-wide site that consists of buildings and areas that formerly housed electrical transformers. Parcel B is also divided into redevelopment blocks that have been assigned redevelopment block numbers to help identify areas of Parcel B that are associated with specific planned reuses. The revised HHRA and the proposed remedial alternatives are based on redevelopment blocks. The table below lists the associated IR sites, the planned reuses, and the HHRA exposure scenario for each redevelopment block at Parcel B.

Parcel B Installation Restoration and Site Inspection Sites

Remedial Investigation Sites :

07	24	51
10	26	60
18	42	61
20	46	62
23	50	

Site Inspection Sites :

31 45

*IR-06 and IR-25 moved to Parcel C

Redevelopment Block	IR Site	Planned Reuse	HHRA Exposure Scenario
1	Part of 18	Mixed Use	Residential
2	Parts of 07 and 18	Research and Development	
3	07	Research and Development	
4	Part of 62	Mixed Use	
5	Parts of 62 and 23	Research and Development	
6	61 and part of 23	Research and Development	
7	42 and SI-31	Mixed Use	
8	10	Mixed Use	
9	Part of 24	Mixed Use	
12	20 and part of 24	Mixed Use	Residential
15	Part of 26	Mixed Use	
16	Part of 26	Educational/Cultural	Industrial

Redevelopment Block	IR Site	Planned Reuse	HHRA Exposure Scenario
BOS-1	Parts of 07 and 18	Open Space	Recreational
BOS-2	60 and part of 24	Open Space	
BOS-3	Part of 26	Open Space	

More than 80 percent of Hunters Point Shipyard consists of relatively level lowlands that were mostly constructed by placing borrowed fill material from a variety of sources, including serpentinite bedrock from the shipyard, construction debris, and waste materials (such as used sandblast materials). The fill supported new buildings, construction, and in some cases filled the margin of San Francisco Bay. Most of Parcel B is located in the lowlands, with surface elevations between 0 to 10 feet above mean sea level. No threatened or endangered species are known to inhabit Hunters Point Shipyard or its vicinity (PRC 1996). The ecology at Parcel B is limited to plant and animal species adapted to an industrial environment. Viable terrestrial habitat is inhibited at Parcel B because about 75 percent of the ground surface is covered by pavement and buildings. However, potential ecological receptors near the shoreline areas of Parcel B were not previously studied. Therefore, the Navy investigated the shoreline areas, and this TMSRA evaluates potential risks to these shoreline receptors, including benthic invertebrates, birds, and mammals.

The geologic setting at Parcel B includes geologic units that include, from youngest (shallowest) to oldest (deepest) Artificial Fill; Undifferentiated Upper Sand Deposits; Bay Mud Deposits; Undifferentiated Sedimentary Deposits; and Franciscan Complex Bedrock. The hydrostratigraphic units at Parcel B are the A-aquifer, the aquitard zone, the B-aquifer, and a bedrock water-bearing zone.

PARCEL B REMEDIAL AND REGULATORY ACTIVITIES SINCE THE 1997 RECORD OF DECISION

The Navy has conducted a number of remedial and removal actions since the ROD was signed in October 1997 (see the callout box on the following page). These actions reduced or eliminated certain risks to human health and ecological receptors at Parcel B. The Navy prepared two explanations of significant differences that modified the remedy for soil in the ROD: one in 1998 that changed the maximum excavation depth to 10 feet, and one in 2000 that updated cleanup goals for soil. The Navy now has a better understanding of site conditions gained during the remedial actions that indicates additional remedies for protection of human health and the environment should be evaluated and that amending the ROD should be considered. The five-year review (Tetra Tech 2003d) concluded that the remedy selected in the ROD (Navy 1997) should be modified to be protective in the long term. The BCT has therefore extended the schedule of CERCLA activities (contained in the FFA) to incorporate modifications to the Parcel B remedy and support preparation of this TMSRA.

Specifically, the excavation and off-site disposal remedy selected in the ROD would not be protective in the long term as it was originally envisioned because the conceptual site model that formed the basis for the remedy was incomplete. The discrete release of chemicals, referred to as the "spill model," was the basis for the remedial action selected in the ROD. Although this conceptual model worked well at many areas of Parcel B, the spill model did not account for all areas where chemical concentrations exceeded cleanup goals. A group of metals related to the bedrock fill quarried to build HPS in the 1940s consistently exceeded cleanup goals across Parcel B. These metals are naturally occurring in the local HPS bedrock and were distributed throughout all parcels, including Parcel B, as HPS was built. The resulting distribution of ubiquitous metals concentrations in soil is nearly random across the parcel and the spill model for release does not apply.

Remedial and Removal Actions at Parcel B since the ROD

Soil:

- **Exploratory Excavation Removal Action, 1996-1997:** A total of 1,700 cubic yards of stained soil, asphalt, and concrete was removed from five sites.
- **Remedial Action Excavations, 1998-2001:** A total of 101,600 cubic yards of contaminated soil was removed from 106 areas.
- **Fuel-Related Excavations, 2004-2005:** A total of 9,800 cubic yards of contaminated soil was removed from two areas.

Groundwater:

- **Remedial Action Monitoring Program, 1999 and ongoing:** Continuous quarterly groundwater monitoring for 32 quarters; 39 wells currently in program.
- **Storm Drain Infiltration Study, 1997:** A study found no impacts to the system from contaminated groundwater.
- **Chromium VI Delineation Study, 2002:** An investigation found the extent of chromium VI in groundwater was limited to one well.

In the TMSRA, the term "ubiquitous" refers to metals that are naturally occurring or are in the same concentration ranges as naturally occurring metals in the source material (including material from the same geologic formations in the San Francisco area) used for filling operations at HPS. The Navy acknowledges that industrial sources of metals exist at HPS and there is a potential that some concentrations of metals could have sources other than naturally occurring materials. The Navy has worked to remove these sources during the response actions taken to date. The Navy acknowledges that the regulatory agencies do not agree with the Navy's position that ubiquitous metals are naturally occurring. Remedial alternatives developed in this TMSRA address these concentrations of metals, regardless of their source.

In addition to identifying the ubiquitous nature of several metals in the bedrock fill, sampling and excavation during the remedial action found that the areas at IR-07 and IR-18 contained fill with a high proportion of demolition debris. The highly nonuniform distribution of chemicals within the debris fill also did not conform to the spill model and, consequently, excavations in this area often greatly exceeded the originally planned extent of the removals. Furthermore, methane was detected in soil gas at a small area of the debris fill at IR-07. In addition, radiological contamination is present at Parcel B that was not known when the ROD was prepared. The debris fill, methane, and radiological contamination created additional needs to update the conceptual site model.

Updates to the risk assessment methodology and the associated risk estimates for groundwater are also needed. The toxicity characteristics of VOCs have been updated since the ROD was prepared. VOCs are now considered more toxic via the inhalation pathway than when the ROD was prepared. In addition, concentrations of VOCs in the area of IR-10 were found to be an order of magnitude higher than was known when the ROD was prepared. Consequently, intrusion of VOC vapors into buildings is considered a more significant human health risk than it was previously. The risk assessment also needs to be updated to incorporate new information available from the more than 7 years of groundwater monitoring data gathered at Parcel B, including the detection of chromium VI and mercury in groundwater.

This TMSRA report includes an update to the site conceptual model for soil and groundwater, a revised HHRA, and a SLERA and, based on these updates, reevaluates remedial alternatives addressing the nine criteria described in the NCP at 40 CFR 300.430(e)(9)(iii).

UPDATED RISK EVALUATION SUMMARY

The HHRA presented in this TMSRA report revises the previous HHRAs to account for the data collected for soil during the 1998 to 2001 and 2004 to 2005 soil removals and to incorporate regulatory guidance and toxicological criteria that have changed since 2000. Soil data associated with sampling locations excavated and removed during the activities in 1998 to 2001 and 2004 to 2005 are excluded from the HHRA. The HHRA in this TMSRA was completed before the start of the radiological removal actions at Parcel B; consequently, some samples included in the HHRA have since been excavated and removed. In addition, data for groundwater collected up to and including quarter 20 (October to December 2004) as part of the Parcel B remedial action monitoring program are included in the HHRA. Lastly, the HHRA was revised based on BCT agreements during 2003 and 2004.

The HHRA in the TMSRA addresses chemicals that are not radioactive. A radiological addendum to the TMSRA was prepared to evaluate remedial alternatives for radiological contamination. The TMSRA radiological addendum addresses cumulative risk from chemical and radiological contaminants. Both chemical and radiological contaminants will then be addressed together in the proposed plan.

The HHRA estimated cancer risks and noncancer hazards from exposure to chemicals of potential concern in all affected environmental media for each pathway identified as potentially complete. Both total and incremental risks were evaluated for exposure to soil at Parcel B. For the total risk evaluation, all detected chemicals were included as chemicals of potential concern regardless of concentration, except for the essential nutrients calcium, magnesium, potassium, and sodium. The total risk evaluation estimates the risks posed by chemicals at the site, including any present at concentrations at or below ambient levels. For the incremental risk evaluation, the essential nutrients and metals with maximum measured concentrations below Hunters Point ambient levels were excluded as soil chemicals of potential concern. The incremental risk evaluation estimates risks posed by chemicals at the site that are not at or below ambient levels. The chemicals at Parcel B determined to pose a potential unacceptable risk were identified as chemicals of concern. Potential unacceptable risk is defined as an excess lifetime cancer risk greater than 1E-06 or a segregated hazard index greater than 1 as indicated by the incremental risk evaluation.

The total risk results for soil show that many exposure areas exceed the excess lifetime cancer risk threshold of 1E-06 or the segregated hazard index threshold of 1.0, based on planned reuse. Planned reuse for Parcel B as developed by the San Francisco Redevelopment Agency includes mixed use, research and development, educational/cultural, and open space (San Francisco Redevelopment Agency 1997). Under the incremental risk evaluation, fewer exposure areas at Parcel B exceed the cancer or noncancer risk thresholds because metals below ambient levels (those considered by the Navy to be naturally occurring) were excluded from the risk analysis. The chemicals of concern in soil at Parcel B include metals above ambient levels and organic compounds such as polynuclear aromatic hydrocarbons, polychlorinated biphenyls, and pesticides.

The results of the HHRA for groundwater show that the risk from exposure to A-aquifer groundwater via vapor intrusion exceeds the excess lifetime cancer risk threshold of 1E-06 in several areas at Parcel B. The chemicals of concern in groundwater from the vapor intrusion pathway include chlorinated and nonchlorinated hydrocarbons. The B-aquifer was evaluated for all chemicals of potential concern through the domestic use of groundwater pathway. Several organic and inorganic chemicals of potential concern were identified.

The SLERA evaluated potential ecological risks from exposure to shoreline sediments and exposure to groundwater as it interacts with surface water. The SLERA found potential unacceptable risk to benthic invertebrates, birds, and mammals from exposure to several metals, pesticides, and polychlorinated biphenyls in sediment along the shoreline. Likewise, the data evaluated in the SLERA indicate potential risk may be posed by mercury, which was identified as a chemical of concern in groundwater.

A screening evaluation of surface water quality evaluated potential ecological risks from exposure to groundwater as it interacts with surface water. The data evaluated indicate potential risk may be posed by chromium VI, copper, lead, and mercury.

TMSRA Evaluation Process

The general process used to conduct this TMSRA closely follows a typical feasibility study and consists of the following steps: develop remediation goals; develop remedial action objectives; identify general response actions; identify areas that require remediation; and evaluate alternatives based on the nine NCP evaluation criteria. Each of these steps is discussed in the following paragraphs.

Develop Remediation Goals and Groundwater Trigger Levels

Remediation goals were developed for each chemical of concern by comparing the highest concentrations that do not present unacceptable incremental risk with chemical-specific applicable or relevant and appropriate requirements, the laboratory practical quantitation limit, and the ambient level for the chemical of concern, if one was established. Remediation goals were derived for both soil and groundwater and for chemicals of concern identified from both the HHRA and SLERA.

Trigger levels were developed for chemicals of concern identified by the screening evaluation of surface water quality. The trigger levels are unique to each location and are a means of relating the surface water quality criteria to groundwater. Trigger levels provide a means to identify when further studies or remedial action may be required to protect the bay.

Develop Remedial Action Objectives

Remedial action objectives for Parcel B are medium-specific goals that were developed from the incremental risk assessment for protecting human health and the environment. Each remedial action objective specifies (1) the chemicals of concern, (2) the exposure routes and receptors, and (3) an acceptable contaminant concentration or range of concentrations for each medium of concern (such as soil and groundwater).

<u>Remedial Action Objectives for Soil</u>

Remedial action objectives for Parcel B soil were developed based on human health receptors and results of the incremental risk assessment. The following remedial action objective applies to Parcel B soil:

- Prevent exposure to organic and inorganic chemicals in soil above the remediation goals developed in the HHRA for carcinogens or noncarcinogens for the following exposure pathways:
  - Ingestion of, outdoor inhalation of, and dermal exposure to soil from 0 to 10 feet below ground surface by residents in areas zoned for research and development or mixed use reuse
  - Ingestion of homegrown produce by residents in areas zoned for research and development or mixed use reuse
  - Ingestion of, outdoor inhalation of, and dermal exposure to soil from 0 to 10 feet below ground surface by industrial workers in areas zoned for educational and cultural reuse
  - Ingestion of, outdoor inhalation of, and dermal exposure to soil from 0 to 2 feet below ground surface by recreational users in areas zoned for open space reuse
  - Soil ingestion, outdoor air inhalation, and dermal exposure to soil from 0 to 10 feet below ground surface by construction workers in all areas
- Prevent exposure to VOCs in soil gas at concentrations that would pose unacceptable risk via indoor inhalation of vapors. Remediation goals for soil gas will be established during the RD

The presence of methane in soil gas at concentrations that could be explosive poses a risk to human health at Parcel B. As a result, the following remedial action objective applies to soil at Parcel B:

- Prevent presence of methane in soil gas above a concentration of 1.25 percent by volume in air.

The SLERA indicates a potential risk to benthic invertebrates, birds, and mammals from several metals, pesticides, and polychlorinated biphenyls in sediment along the shoreline of Parcel B. Similar or higher concentrations of these chemicals also exist in upland soil. As a result, the following remedial action objective applies to soil and shoreline sediment at Parcel B:

- Prevent exposure of ecological receptors to organic and inorganic compounds in soil and shoreline sediment above remediation goals.

Remedial Action Objectives for Groundwater

Remedial action objectives for Parcel B groundwater were developed based on (1) the incremental human health risks through inhalation of VOCs in indoor air (vapor intrusion) from the A-aquifer groundwater, (2) the incremental human health risks through the domestic use exposure pathway from the B-aquifer, (3) the incremental human health risks to construction workers from dermal exposure and inhalation from the A-aquifer, and (4) risks to ecological receptors from potential migration of chemicals of concern to San Francisco Bay. The following remedial action objectives apply to groundwater at Parcel B:

- Prevent exposure to VOCs in A-aquifer groundwater above remediation goals via indoor inhalation of vapors from groundwater.
- Prevent direct exposure to the B-aquifer groundwater that may contain chemicals of concern through the domestic use pathway.
- Prevent or minimize exposure to metals, VOCs, and semivolatile organic compounds in the A-aquifer groundwater from dermal exposure and inhalation of vapors from groundwater by construction workers above remediation goals.
- Prevent or minimize migration of chromium VI, copper, lead, and mercury in A-aquifer groundwater that would result in concentrations of chromium VI above 50 micrograms per liter (μg/L), copper above 28.04 μg/L, lead above 14.44 μg/L, and mercury above 0.6 μg/L in the surface water of San Francisco Bay. This remedial action objective is intended to provide protection of the beneficial uses of the bay, including protection of ecological receptors.

Identify General Response Actions

General response actions are responses or remedies intended to meet remedial action objectives. General response actions identified for soil, sediment, and groundwater at Parcel B include no action, institutional controls, removal and disposal, treatment, and containment. Process options were then initially screened and then analyzed in detail to select the technologies and processes that were appropriate to address chemicals of concern at Parcel B. Based on this screening and evaluation, soil and sediment treatment technologies and groundwater removal and containment technologies were eliminated from further consideration.

Identify Remedial Alternatives

The retained process options were combined into remedial alternatives to meet remedial action objectives and to satisfy applicable or relevant and appropriate requirements. Remedial alternatives were derived using experience and engineering judgment that formulated the process options into the most plausible site-specific remedial actions. The soil and groundwater alternatives developed for further analysis are presented below.

Alternative S-1: No Action: For this alternative, no remedial action would be taken. Soil would be left in place without implementing any response actions. The no-action response is retained throughout the evaluation process as required by the NCP to provide a baseline for comparison with other alternatives.

Alternative S-2: Institutional Controls, Maintained Landscaping, and Shoreline Revetment: Alternative S-2 consists of institutional controls, maintained landscaping, and construction of a shoreline revetment that, together, will meet all applicable or relevant and appropriate requirements and remedial action objectives. The institutional controls include access restrictions and covenants to restrict use of property that will be implemented parcel-wide for all of the redevelopment blocks. The maintained landscaping will prevent potential exposure to asbestos (that may be present in surface soil and transported by wind erosion) that would not be addressed by institutional controls alone. The shoreline revetment would be constructed to protect the entire shoreline for the redevelopment blocks where the revetment is necessary.

Alternative S-3: Excavation, Methane and Mercury Source Removal, Disposal, Institutional Controls, Maintained Landscaping, and Shoreline Revetment: Alternative S-3 consists of soil excavation and off-site disposal and maintained landscaping and institutional controls similar to Alternative S-2. Alternative S-3 contains the same maintained landscaping and shoreline revetment components that are discussed with Alternative S-2. Areas where organic compounds (including the methane source), mercury, and lead are chemicals of concern would be excavated to remediate these chemicals of concern to remediation goals. This alternative will provide a more permanent remedy to remove contaminants where excavation is feasible. Parcel-wide institutional controls will also be applied to mitigate the risk exposure to other chemicals of concern in soil that are not practical to remediate by excavation and disposal.

Methane venting will be considered as a contingency in the event that excavation of the methane source area does not adequately control the methane emissions or if excavation is infeasible based on site conditions (for example, if methane is produced from organic material in the native sediments instead of from identifiable construction debris).

Alternative S-4: Covers, Methane and Mercury Source Removal, Institutional Controls, and Shoreline Revetment: Alternative S-4 consists of covers to remove the exposure pathway to soil contaminants and institutional controls similar to Alternatives S-2 and S-3. Alternative S-4 also contains the same methane and mercury source removal components that are described in Alternative S-3 and the shoreline revetment component included in Alternatives S-2 and S-3. This alternative provides physical barriers to cut off the soil exposure pathways at Parcel B. Covers included in this alternative may include new covers and existing or future building footprints, roads, and parking lots. Institutional controls are included in this alternative for both short-term and long-term mitigation of risk exposure. In addition to institutional controls similar to those required for Alternative S-2, institutional controls will also be included that would require maintenance of covers.

Alternative S-5: Excavation, Methane and Mercury Source Removal, Disposal, Covers, Soil Vapor Extraction, Institutional Controls, and Shoreline Revetment: Alternative S-5 consists of a combination of soil excavation (including methane and mercury source removal) and off-site disposal, covers, soil vapor extraction for VOCs, institutional controls, and shoreline revetment. This alternative was developed as a combined alternative to (1) remove and dispose of organic chemicals of concern, mercury, and lead, as described in Alternative S-3, (2) implement and maintain block-wide covers, as described in Alternative S-4, (3) remove and treat VOCs in soil using soil vapor extraction, and (4) implement the institutional controls and construct the shoreline revetment, as described in Alternative S-2.

Alternative GW-1: No Action: For this alternative, no remedial action will be taken for groundwater. Groundwater conditions will be left as is, without implementing any response actions. The no-action response is retained throughout the evaluation process as required by the NCP to provide a baseline for comparison with other alternatives.

Alternative GW-2: Long-Term Groundwater Monitoring and Institutional Controls: Alternative GW-2 consists of groundwater monitoring and institutional controls. This alternative was developed as a method for monitoring contaminants present at low concentrations in groundwater. Additionally, groundwater monitoring will be used to confirm site conditions and ensure that, over time, the potential exposure pathways remain incomplete. Two groundwater monitoring wells have been installed near well IR26MW47A to monitor concentrations of mercury in groundwater. A third well will be installed within the area of Excavation EE-05 after the final remedy is selected and the mercury source removal is completed. Institutional controls are also included in this alternative to effectively manage risk by preventing exposure and use of the groundwater.

Alternatives GW-3A and GW-3B: *In Situ* Treatment, Groundwater Monitoring, and Institutional Controls: Alternatives GW-3A and GW-3B consist of *in situ* treatment of the contaminant plumes in addition to groundwater monitoring and institutional controls similar to Alternative GW-2. Alternatives GW-3A and GW-3B involve using different *in situ* treatment reagents. Alternative GW-3A uses a slow-release substrate designed to promote anaerobic bioremediation to degrade chlorinated chemicals of concern to nontoxic compounds. Alternative GW-3B uses a zero-valent iron slurry as an additive that creates a chemically reducing environment in the aquifer that mineralizes chlorinated chemicals similar to the bioremediation reaction. An additional reagent will be used, as needed, to mitigate dissolved metals in groundwater. Removal of the mercury source as part of the soil remedy is expected to mitigate mercury in groundwater so that *in situ* treatment is not necessary. The need for treatment of chromium VI, copper, and lead will be based on the further analysis of groundwater data against trigger levels that will occur during the RD. These alternatives were selected to reduce the required time to meet the groundwater remedial action objectives and, as a result, the length of groundwater monitoring and possibly the time required for institutional controls.

Evaluation of Alternatives Based on NCP Evaluation Criteria

Each remedial alternative developed in the TMSRA and the original remediation alternatives proposed in the 1997 ROD were evaluated in comparison to the two threshold and five balancing NCP evaluation criteria (see adjacent box). Comparison to the two modifying criteria of regulatory and community acceptance will be included in the final TMSRA report and future proposed plan after comments are received; further discussion of these criteria is not included in this report. A comparative analysis was then conducted to evaluate the relative performance of the five soil and three groundwater remedial alternatives developed for Parcel B.

NCP Evaluation Criteria

Threshold Criteria:
- Overall protection of human health and the environment
- Compliance with ARARs

Balancing Criteria:
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

Modifying Criteria:
- Regulatory agency acceptance
- Community acceptance

Evaluation Results for Soil and Groundwater Alternatives

An overall rating was assigned to each alternative. Alternatives S-2 through S-5 meet the threshold criteria. Alternative S-5 is rated excellent overall for the five balancing NCP evaluation criteria. Alternative S-5 is the most effective, with both excavation and covers, although it has the highest cost ($12.4 million). Alternative S-3, rated good, is more effective than Alternative S-2 because contaminants are removed, although it is more expensive ($10.7 million). Alternative S-4, rated very good, is more effective than Alternatives S-2 or S-3 and is similar in cost ($11.9 million) to Alternative S-5. Alternative S-2, rated good, is easiest to implement and least expensive ($5.5 million). Alternative S-1 is rated as not acceptable. The original ROD soil alternative does not address the methane and mercury source areas (because they are below 10 feet below ground surface) and radiological contamination and would not be protective of human health and the environment and, therefore, is rated as not acceptable. The total cost for full implementation of the original ROD soil alternative would likely require at least an additional $60 million, for a total of more than $100 million.

Alternative GW-3A, rated excellent, has the highest overall rating. The treatment in Alternative GW-3A effectively reduces risks to human health and environment and has a moderate cost ($2.4 million). Alternative GW-3B is rated very good, but the higher cost makes it slightly less advantageous ($2.8 million). Alternative GW-2, rated good, is easy to implement and least expensive ($1.8 million), but it is not as effective as Alternatives GW-3A and GW-3B. Alternative GW-1 and the original ROD groundwater alternative are rated as not acceptable. The total cost for full implementation of the original ROD groundwater alternative would likely require at least an additional $2 million, for a total of more than $10 million.

Table ES-1 summarizes each alternative's rating under the seven evaluation criteria. The ranking categories used in Table ES-1 and in the discussion of the alternatives are (1) protective or not protective, and meets applicable or relevant and appropriate requirements (ARAR) or does not meet ARARs, for the two threshold criteria; and (2) excellent, very good, good, poor, and not acceptable for the five balancing criteria.

TABLES

TABLE ES-1: RANKING OF REMEDIAL ALTERNATIVES FOR SOIL AND GROUNDWATER

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

	Overall Protection of Human Heath and the Environment [a]	Compliance with ARARs [a]	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost ($ Million)	Overall Rank by Alternative
SOIL ALTERNATIVES								
Alternative S-1: No Action	Not Protective	Not Applicable	Not acceptable	Poor	Very Good	Excellent	0	Not acceptable
Alternative S-2: Institutional Controls, Maintained Landscaping, and Shoreline Revetment	Protective	Meets ARARs	Good	Poor	Good	Very Good	5.5	Good
Alternative S-3: Excavation, Methane and Mercury Source Removal, Disposal, Maintained Landscaping, Institutional Controls, and Shoreline Revetment	Protective	Meets ARARs	Very Good	Poor	Good	Very Good	10.7	Good
Alternative S-4: Covers, Methane and Mercury Source Removal, Disposal, Institutional Controls, and Shoreline Revetment	Protective	Meets ARARs	Very Good	Poor	Very Good	Very Good	11.9	Very Good
Alternative S-5: Excavation, Methane and Mercury Source Removal, Disposal, Covers, SVE, Institutional Controls, and Shoreline Revetment	Protective	Meets ARARs	Excellent	Good	Very Good	Very Good	12.4	Excellent
Original ROD: Excavation, Disposal, and Institutional Controls	Not Protective	Does Not Meet ARARs	Poor	Poor	Poor	Poor	>60	Not acceptable
GROUNDWATER ALTERNATIVES								
Alternative GW-1: No Action	Not Protective	Not Applicable	Poor	Poor	Very Good	Excellent	0	Not acceptable
Alternative GW-2: Long-Term Monitoring of Groundwater and Institutional Controls	Protective	Meets ARARs	Good	Poor	Excellent	Excellent	1.8	Good
Alternative GW-3A: *In Situ* Groundwater Treatment with Biological Substrate Injection, Reduced Groundwater Monitoring, and Institutional Controls	Protective	Meets ARARs	Excellent	Excellent	Very Good	Very Good	2.4	Excellent
Alternative GW-3B: *In Situ* Treatment with ZVI Injection, Reduced Groundwater Monitoring, and Institutional Controls	Protective	Meets ARARs	Very Good	Excellent	Very Good	Very Good	2.8	Very Good
Original ROD: Line Storm Drains, Remove Steam and Fuel Lines, Institutional Controls, and Groundwater Monitoring	Not Protective	Meets ARARs	Poor	Poor	Excellent	Excellent	>2	Not acceptable

Legend:

- ○ Not acceptable
- ◔ Poor
- ◑ Good
- ◕ Very Good
- ● Excellent

Notes:

a	Overall protection of human health and the environment and compliance with ARARs are threshold criteria and alternatives are judged as either meeting or not meeting the criteria.
ARAR	Applicable or relevant and appropriate requirement
SVE	Soil vapor extraction
ZVI	Zero-valent iron

1.0 INTRODUCTION

This report is a technical memorandum in support of a record of decision (ROD) amendment (TMSRA) for Parcel B at Hunters Point Shipyard (HPS) in San Francisco, California (see Figure 1-1). The overall objective of this report is to provide information to support a future proposed plan and ROD amendment that will align the final remedy for Parcel B with its planned reuse and address the recommendations summarized in the first five-year review of remedial actions (Tetra Tech EM Inc. [Tetra Tech] 2003d). This TMSRA focuses on activities the Navy has conducted since the ROD was signed in October 1997.

Pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) (Title 42 *United States Code* [U.S.C.] Section (§) 9601, et seq.), the Superfund Amendments and Reauthorization Act of 1986 (SARA), and Executive Orders 12580 and 13016, the Department of Defense (DoD) has the authority to respond to the release of a CERCLA hazardous substance on property owned by the United States, under the jurisdiction of DoD. SARA § 211 codified at Title 10 U.S.C. § 2701, et seq., established the Defense Environmental Restoration Program and required DoD to respond to the release of CERCLA hazardous substances, pollutants, and contaminants in accordance with CERCLA § 120. DoD established the Installation Restoration (IR) Program under the Defense Environmental Restoration Program to identify and respond to DoD sites where there has been a release of a CERCLA hazardous substance. The Department of the Navy is the lead federal agency that manages the HPS property and is responsible for executing the requirements of the Defense Environmental Restoration Program. The Navy is cleaning up Parcel B at HPS under the IR Program to address past releases of CERCLA hazardous substances. HPS was included on the National Priorities List in November 1989.

As the lead agency, the Navy has authority over evaluation of risk, selection of the remedial alternative, and overall public participation at HPS. The Navy is coordinating with the U.S. Environmental Protection Agency, Region 9 (EPA); the California Environmental Protection Agency (Cal/EPA) Department of Toxic Substances Control, Region 2 (DTSC); and the San Francisco Bay Regional Water Quality Control Board (Water Board) to develop and select remedial alternatives in support of a ROD amendment for Parcel B. The Navy coordinates activities at HPS with the regulatory agencies under the terms of a federal facility agreement (FFA). The FFA was prepared in 1992 and signed by representatives of the Navy, EPA, DTSC, and the Water Board. Representatives of the Navy, EPA, DTSC, and Water Board are collectively referred to as the Base Realignment and Closure (BRAC) Cleanup Team (BCT) for HPS.

Currently, HPS is divided into six parcels: B, C, D, E, E-2, and F. Figure 1-2 identifies these six parcels at HPS. In 1992, the Navy divided HPS into five contiguous parcels (A through E) to expedite remedial action and land reuse. In 1996, the Navy added a sixth parcel (Parcel F), also known as the offshore area. In September 2004, the Navy designated the landfill area in Parcel E as a separate parcel, Parcel E-2. In December 2004, the Navy transferred Parcel A to the San Francisco Redevelopment Agency. Much of the work the Navy has completed at HPS has been part of the Navy's IR Program. Figure 1-3 shows the IR and site inspection (SI) sites at Parcel B. Parcel B, which includes 59 acres on the north side of HPS, is the focus of this TMSRA.

1.1 PARCEL B CERCLA PROCESS

EPA guidance describes the CERCLA remedial process as a series of several, progressive steps for achieving cleanup and release of the environmental issues at a site for future reuse (EPA 1988b). The typical sequence includes a preliminary assessment and site inspection, remedial investigation (RI), feasibility study (FS), proposed plan, public comment period, ROD, remedial design (RD), remedial action, and post-construction reporting. The Navy completed the FFA for HPS with the regulatory agencies in 1992 to document the process and to provide a schedule for CERCLA activities at HPS. Table 1-1 summarizes the CERCLA-related activities conducted at Parcel B. Parcel B has completed the steps through post-construction reporting (including the five-year review); however, the updated site information that became available during the remedial action indicates that modifications to the selected soil and groundwater remedies should be considered. The five-year review (Tetra Tech 2003d) concluded that the remedy selected in the ROD (Navy 1997) should be modified to be protective in the long term. The BCT has therefore extended the schedule of CERCLA activities (contained in the FFA) to incorporate modifications to the Parcel B remedy and support preparation of this TMSRA.

A ROD amendment will be proposed for Parcel B by the Navy if the Navy determines that proposed changes to the selected remedy based upon the evaluations in this TMSRA will "fundamentally alter the basic features of the selected remedy with respect to scope, performance, or cost" as described in the NCP at Title 40 *Code of Federal Regulations* (CFR) 300.435(c)(2)(ii). For example, the consideration of parcel-wide covers to address soil contamination instead of excavation may represent a fundamental change in the scope of the remedy. For groundwater, the addition of active groundwater treatment methodologies to the remedy may be a fundamental change in the scope.

The updated information about the ubiquitous nature of certain metals in soil; the presence of methane, mercury, and radiological contamination; the need to update certain cleanup levels; and the more comprehensive understanding of groundwater; together with the planned land use, indicate the need to revise the conceptual site model, evaluate additional remedial actions, and evaluate amending the ROD. This TMSRA provides the support for the decisions regarding remediation alternatives, in the same way that the FS supported the initial proposed plan and ROD.

This document addresses chemicals that are not radioactive. Potential radiological contamination is addressed in a radiological addendum to the TMSRA (Tetra Tech EC, Inc. 2007). Both chemical and radiological contaminants will then be addressed together in the proposed plan.

1.2 NEED FOR REEVALUATION OF CURRENT REMEDY

The five-year review (Tetra Tech 2003b) concluded that the remedy selected in the ROD (Navy 1997) should be modified to be protective in the long term. This section describes the rationale for reevaluating the current remedy based on the updated information gained at the site and necessary revisions to the conceptual site model (see Section 2.2 for a discussion of the conceptual site model). Updated information includes items such as the ubiquitous nature of metals in soil across Parcel B, the presence of methane and mercury, the findings of the screening-level ecological risk assessment (SLERA), changes in toxicity criteria, and findings from removal actions to address radiological contaminants.

1.2.1 Soil

The discrete release of chemicals, referred to as the "spill model," was the basis for the remedial action selected in the ROD. Under this conceptual model, high chemical concentrations occur near the center of the release and concentrations decrease outward. The delineation process used in the remedial action followed this model: successive "step-out" samples were collected from release areas identified by the remedial investigation to define the extent of the release outward until all samples contained concentrations that were less than the ROD cleanup goals. The spill model for chemical releases was appropriate for many areas at Parcel B. The Navy successfully delineated and removed all contaminants at concentrations above cleanup goals at 93 of 106 excavations implemented for the remedial action. The ubiquitous distribution of metals in soil, especially manganese, led to reevaluation of the remedy at the remaining 13 excavations at Parcel B.

The significant additional information gained from sampling and excavation during the remedial action indicated that the spill model did not account for all areas where chemical concentrations exceeded cleanup goals. As a result, the Navy recognized that the spill model needed to be supplemented to account for these other areas. A group of metals, especially arsenic and manganese, consistently exceeded cleanup goals at locations across Parcel B. The widespread distribution of this group of metals in soil at Parcel B (that is, their ubiquitous nature) is related to the occurrence of these metals in the local bedrock that was quarried for fill during the expansion of HPS in the 1940s. These metals occur naturally in the Franciscan Formation bedrock (especially in the serpentinite, chert, and basalt rock types) and were distributed throughout all parcels, including Parcel B, as HPS was built. Although it is possible that some releases of these metals could have occurred from Navy activities, the range of concentrations of these metals at Parcel B is consistent with the range of concentrations in local bedrock. The resulting distribution of metals concentrations in soil is nearly random across the parcel, and the spill model for release does not apply. However, the concentrations of metals in the bedrock fill sometimes exceed the ROD cleanup goals, and this fact is the primary reason that the "step-out" delineation process was not successful everywhere on Parcel B. Application of the spill conceptual model to the ubiquitous metals would result in the excavation of most of the bedrock fill at Parcel B to a depth of 10 feet below ground surface (bgs), which is the depth required by the ROD. Therefore, the Navy recognized the need to supplement the conceptual model to account for the ubiquitous distribution of metals in soil. Remedial alternatives in the TMSRA address ubiquitous metals using options such as containment beneath covers and institutional controls.

In the TMSRA, the term "ubiquitous" refers to metals that are naturally occurring or are in the same concentration ranges as naturally occurring metals in the source material (including material from the same geologic formations in the San Francisco area) used for filling operations at HPS. The Navy acknowledges that industrial sources of metals exist at HPS and there is a potential that some concentrations of metals could have sources other than naturally occurring materials. The Navy has worked to remove these sources during the response actions taken to date. The Navy acknowledges that the regulatory agencies do not agree with the Navy's position that ubiquitous metals are naturally occurring. Remedial alternatives developed in this TMSRA address these concentrations of metals, regardless of their source.

In addition to identifying the ubiquitous nature of several metals in the bedrock fill, sampling and excavation during the remedial action found that the areas at IR-07 and IR-18 contained fill with a high proportion of demolition debris. The highly nonuniform distribution of chemicals within the debris fill also did not conform to the spill model and, consequently, excavations at IR-07 and IR-18 often greatly exceeded the originally planned extent of the removals. Furthermore, methane was detected in soil gas at a small area of the debris fill at IR-07 (see Section 5.0 and Figure 5-5 for more discussion of methane). In addition, radiological contamination is present at Parcel B that was not known when the ROD was prepared. The debris fill, methane, and radiological contamination created additional needs to update the conceptual site model and the TMSRA considers remediation alternatives to address this new understanding of site conditions.

Comparison of the remedial action envisioned in the ROD to the actions completed to date illustrates the large difference between the planned and actual site conditions at Parcel B. The estimate in the ROD for the remedial action included removal of 38,000 cubic yards of soil over a period of 3 to 6 months at a cost of $11.2 million. The remedial action at Parcel B removed over 100,000 cubic yards of soil over a period of 31 months at a cost of more than $40 million. (The 31 months when excavation occurred extended from July 1998 to December 2001.) Figure 1-4 compares the excavation areas estimated in the ROD with the actual remedial action excavations.

The updated site information and results from the remedial actions completed at Parcel B indicate the need to reevaluate the remedies selected in the ROD. The selected remedy would not be protective of human health and the environment based on the updated information about the site and revisions to human health toxicity criteria. The following is a summary of the reevaluation of the original remedy against the two threshold and five balancing remedy selection criteria listed in the NCP at 40 CFR 300.430(e)(9)(iii). Section 6.0 presents a more detailed discussion, including a comparison of the original remedy to other alternatives developed in the TMSRA.

Current Soil Remedy

- Protectiveness – the original ROD alternative did not consider excavation below 10 feet bgs and it is likely that deeper excavation would be necessary to remove the source of methane at IR-07 and mercury at IR-26. The original ROD alternative also did not account for radiological contamination. Therefore, the rating for the original ROD alternative for overall protection of human health and the environment would be not protective based on the methane and mercury sources remaining in place and radiological contamination.

- Compliance with applicable or relevant and appropriate requirements (ARAR) – concentrations of methane in soil gas exceed allowable levels identified in chemical-specific ARARs; the current remedy would not meet the ARARs identified in the TMSRA.

- Long-term effectiveness – the current remedy would rank as poor based on the methane and mercury sources remaining in place.

- Reduction of toxicity, mobility, and volume through treatment – excavation does not involve treatment and the current remedy ranks poor and would continue to rank as poor based on updated information about the site.

- Short-term effectiveness – the current remedy would rank poor on this criterion based on the much longer time needed for implementation (more than 31 months to date versus 3 to 6 months) and the subsequent much longer exposure to workers and the community. The current remedy would not achieve the remedial action objectives unless much of the bedrock fill and the debris fill area were removed, resulting in more exposure to workers and the community.

- Implementability – the current remedy would rank as poor based on the large-scale operation to remove bedrock fill and the debris fill area.

- Cost – the current remedy would rank as poor based on the significantly higher (more than 3.5 times) cost required (more than $40 million to date versus $11.2 million). Cost for full implementation would likely total more than $100 million.

Overall, the reevaluation of the current remedy would result in a determination of "not protective" based on protectiveness and compliance with ARARs.

In summary, the excavation and off-site disposal remedy for soil, as described in the ROD, would not be protective in the long term. Knowledge that the Navy has gained during the remedial action shows the need to (1) supplement the conceptual model to include the random distribution of ubiquitous metals in soil, account for methane, mercury, radiological contamination, and the debris fill area at IR-07 and IR-18, (2) evaluate amending the ROD, and (3) evaluate additional remedial actions for soil at Parcel B. This TMSRA evaluates potential modifications to the remedy for soil in accordance with revisions to the conceptual model to support additional remedial actions that will address remaining risks.

1.2.2 Groundwater

The remedy selected in the ROD for groundwater included lining storm drains, removing steam and fuel lines, restricting use of groundwater, and groundwater monitoring. However, the remedy selected for groundwater in the ROD should be revised based on (1) the large amount of new information available from the more than 7 years of groundwater monitoring data gathered at Parcel B, including the detection of chromium VI and mercury in groundwater, and

(2) changes in the toxicity estimates and exposure assumptions for volatile organic compounds (VOC) since the ROD was prepared. Concentrations of VOCs in the area of IR-10 were found to be an order of magnitude higher than was known when the ROD was prepared. In addition, the toxicity characteristics of VOCs have been updated since the ROD was prepared. VOCs are now considered more toxic via the inhalation pathway than they were when the ROD was prepared. Consequently, intrusion of VOC vapors into buildings is a more significant human health risk. In particular, the groundwater remedy in the ROD did not identify the VOC plume at IR-10 as requiring remediation. However, this plume may pose a much greater risk than was estimated in the ROD. The ROD does not contain any active remediation options to address the cleanup of VOCs in groundwater.

The Navy has investigated the area of IR-10 in considerable detail since the ROD was prepared. The Navy installed more than 25 new groundwater monitoring wells in the area of IR-10 and conducted treatability studies to investigate methods to clean up the soil and groundwater. Treatability studies using soil vapor extraction (SVE) to remove VOCs from the unsaturated zone and injection of zero-valent iron (ZVI) to destroy VOCs in groundwater were successfully implemented at the IR-10 VOC plume. The TMSRA considers these and other remediation options to address the potential inhalation risks posed by VOCs that remain in soil and groundwater at IR-10.

Similar to the discussion above for soil, the updated site information and results from the remedial actions completed at Parcel B indicate the need to reassess remediation alternatives selected in the ROD. The remedy would not be protective of human health and the environment based on the updated information about the site and revisions to human health toxicity criteria and exposure assumptions. The following is a summary of the reevaluation of the original remedy against the two threshold and five balancing criteria. Section 6.0 presents a more detailed discussion, including a comparison of the original remedy to other alternatives developed in the TMSRA.

Current Groundwater Remedy

- Protectiveness – the current remedy does not include institutional controls to limit access to buildings and the remedy would not be considered protective of VOCs in groundwater that pose an unacceptable risk from vapor intrusion into buildings.

- Compliance with ARARs – the current remedy would meet the ARARs identified in the TMSRA.

- Long-term effectiveness – the current remedy would rank as poor based on the magnitude of potential risks remaining posed by VOCs.

- Reduction of toxicity, mobility, and volume through treatment – the current remedy does not contain any treatment component and, therefore, would rank as poor for this criterion.

- Short-term effectiveness – the current remedy includes only groundwater monitoring and would rank as excellent based on the minimal and controllable exposure to workers during monitoring.

- Implementability – the current remedy would rank as excellent based on the routine nature of groundwater monitoring.

- Cost – the current remedy would rank as poor based on the higher cost required (about $8 million to date versus the ROD estimate of $3.6 million); groundwater monitoring costs would continue to be incurred into the future. Cost for full implementation would likely total more than $10 million.

Overall, the reevaluation of the current remedy would result in a determination of "not protective."

In summary, the remedy for groundwater selected in the ROD needs to be expanded to account for the increased potential risk from VOCs in groundwater and provide remediation alternatives to address this risk. The TMSRA uses the large amount of new information from groundwater monitoring and treatability studies to evaluate modifications to the remedy for groundwater to support additional remedial actions that will address remaining risks.

1.2.3 Shoreline

Potential ecological risk to aquatic receptors along the shoreline of Parcel B was not evaluated in the ROD. The TMSRA contains a SLERA to evaluate risks to aquatic receptors and the TMSRA evaluates remediation alternatives to address these risks. The SLERA concluded that a variety of organic and inorganic chemicals in sediment along the shoreline and mercury in groundwater at IR-26 pose a potential unacceptable risk to aquatic receptors. The ROD needs to be amended to address potential ecological risks.

1.2.4 Radiological

Radiological contamination was not addressed by the ROD; however, radiological contamination is present at Parcel B. The ROD should be amended to memorialize the methods and cleanup goals for radiological contaminants that are being addressed by the basewide radiological removal action. The radiological addendum to the TMSRA evaluates remediation alternatives for the radiological contamination (Tetra Tech EC, Inc. 2007).

1.3 FUTURE LAND USE

Based on the City of San Francisco's reuse plan (San Francisco Redevelopment Agency 1997), Parcel B is expected to be zoned to accommodate mixed uses, including a mixed residential/retail area, a research and development area, a cultural and educational area, and open space. The mixed-use and research and development areas could include single-family homes, upper-story housing, or live/work arrangements and a variety of commercial enterprises, artist studios, retail, and business services on the ground floor. The cultural and educational area could include museums. The open space areas will provide public access and use of the waterfront as well as provide a corridor for the Bay Trail (hiking and bicycle access) close to the shoreline (San Francisco Redevelopment Agency 1997).

1.4 PURPOSE AND ORGANIZATION OF REPORT

This TMSRA is intended to provide support for a future proposed plan and ROD amendment that will align the final remedy with the planned reuses for Parcel B. The TMSRA follows guidance prepared by EPA for cleanup under CERCLA. The TMSRA includes many of the elements of an FS; however, since the Navy already prepared an FS report earlier in the CERCLA process for Parcel B (see additional discussion in Section 1.1), only those elements requiring updates to support or reflect the proposed amendments to the ROD are provided. For example, updates are included for the human health risk assessment (HHRA), the SLERA, and the soil and groundwater characterization, but updates are not necessary for topics where there have been no changes since the ROD (such as climate and topography). The TMSRA includes elements of an FS required by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), including an evaluation of remedial alternatives against the nine NCP evaluation criteria.

The path forward following approval of the TMSRA is an amendment to the Parcel B ROD. An entirely new ROD is not required because much remedial work has been accomplished at Parcel B and many aspects of the existing ROD still apply and will be carried forward. Two main aspects of the ROD are proposed for change; these changes are the focus of the TMSRA: (1) changes to the risk assessment methodology and associated risk estimates, and (2) an updated understanding of site conditions gained during remedial actions that indicates additional remedies for protection of human health and the environment are appropriate.

Changes to the risk assessments include updates to the HHRA and the addition of a SLERA. The updates to the HHRA account for remedial actions completed since the ROD and for changes to exposure assumptions proposed by EPA Region 9. Changes in EPA and Cal/EPA estimates of the toxicity of certain chemicals indicate that additional remedial actions that were not addressed in the ROD are necessary to protect human health. Changes in the toxicity of VOCs that may be inhaled in indoor air is one example where updated toxicity information indicates greater risk to human health than was previously estimated. Furthermore, the ROD did not address potential risk to ecological receptors along the shoreline of Parcel B, and the TMSRA addresses these concerns by providing an ecological assessment of the shoreline areas.

The Navy removed more than 100,000 cubic yards of soil from the parcel, evaluated a large amount of soil analytical data, and conducted quarterly groundwater monitoring for more than 7 years. As a result, the Navy now has a more comprehensive understanding of conditions in soil and groundwater at Parcel B than when the ROD was prepared. Additional remedial actions, not considered in the ROD, are recommended to protect human health and the environment based on this understanding. The updates to site information include:

- The ubiquitous nature of certain metals in soil that was confirmed during the remedial action
- The presence of methane and mercury
- The findings of the SLERA
- The currently planned land uses described in the HPS redevelopment plan (San Francisco Redevelopment Agency 1997)
- An updated groundwater characterization based on 32 quarters of monitoring and changes in concentrations and toxicity criteria for VOCs in groundwater
- The findings from removal actions to address radiological contaminants

After this introduction, this TMSRA includes the following sections:

- **Section 2.0, Parcel B Activities since the ROD**. This section discusses the investigations, treatability studies, and remedial and removal actions conducted since the ROD. This section also summarizes the history of regulatory actions and updates the conceptual site model (CSM) for soil and groundwater at Parcel B.
- **Section 3.0, Updated Risk Evaluation Summary and Remediation Goals**. This section presents a summary of the updated risk to human health and ecological receptors based on the conditions in soil and groundwater and the planned future land uses. Remediation goals are then presented for the chemicals of concern (COC) identified from the HHRA and SLERA.
- **Section 4.0, Remedial Action Objectives, General Response Actions, and Process Options**. This section discusses the remedial action objectives (RAO) for soil and groundwater and summarizes the updated analysis of ARARs. This section identifies general response actions (GRA) that address the RAOs and ARARs. GRAs are screened for effectiveness, implementability, and cost. Process options associated with each GRA are then screened for their technical and economic implementability.
- **Section 5.0, Development and Description of Remedial Alternatives**. This section presents a detailed description of the remedial alternatives based on the process options selected in Section 4.0 that will satisfy the RAOs. Process options recommended for consideration are assembled, singularly or in combination, to create remedial alternatives.
- **Section 6.0, Detailed Analysis of Remedial Alternatives**. This section presents the evaluation of each remedial alternative developed in Section 5.0 and the original ROD remediation alternatives against EPA's nine evaluation criteria. The alternatives are then compared against each other to evaluate their relative advantages and disadvantages with respect to the evaluation criteria.
- **Section 7.0, References**. This section presents a list of documents and support material used to generate this report.

Figures and tables are presented after the end of the section where they are cited. In addition, supporting data, calculations, and evaluations for this TMSRA report appear in the appendices as:

- **Appendix A – HHRA** for soil and groundwater presents a detailed description of the risk methodology and results, including figures and tables for the various exposure scenarios. Section 3.0 summarizes Appendix A.

- **Appendix B – SLERA** for sediment and groundwater presents a detailed description of the risk methodology and results, including figures and tables for the various exposure scenarios. Section 3.0 summarizes Appendix B.

- **Appendix C – Applicable or Relevant and Appropriate Requirements** identifies and evaluates potential federal and State of California ARARs and presents the Navy's determinations on the applicability of these ARARs to the alternatives in this TMSRA. The ARARs are summarized in Section 4.0.

- **Appendix D – Remedial Alternative Cost Estimates** presents detailed costs and associated assumptions for each alternative that were used to support the evaluation of the cost criterion in Section 6.0. Appendix D includes detailed spreadsheets that provide unit costs and quantities for each line item.

- **Appendix E – Beneficial Use Evaluation for Parcel B Groundwater** presents a detailed analysis of the beneficial use of the A-aquifer and the B-aquifer at Parcel B to help define the appropriate exposure scenarios in the HHRA. Section 2.0 summarizes the beneficial use determinations for Parcel B. The discussions presented in Appendix E are also intended to provide information to EPA that may be used to conclude that the A-aquifer should not be considered a potential drinking water source, as has been determined by the Water Board.

- **Appendix F – Analytical Database** presents all Parcel B data for soil and groundwater used in this TMSRA report. The database includes all data for soil and all data for groundwater through November 2004 (quarter 20). This appendix (on compact disk) contains a searchable database of all chemical analytical data for soil and groundwater at Parcel B, including pre-established queries for printing data reports.

- **Appendix G – Correspondence and Guidance** includes letters from EPA and the Water Board concerning the beneficial uses of groundwater at HPS, guidance from the U.S. Department of Defense on principles for enforcement of land-use controls, and a memorandum of agreement between the Navy and DTSC on covenants to restrict the use of property.

- **Appendix H – Chromium VI Investigation Report** contains the draft report prepared to summarize the investigation of chromium VI in groundwater in the area of monitoring well IR10MW12A conducted in 2002.

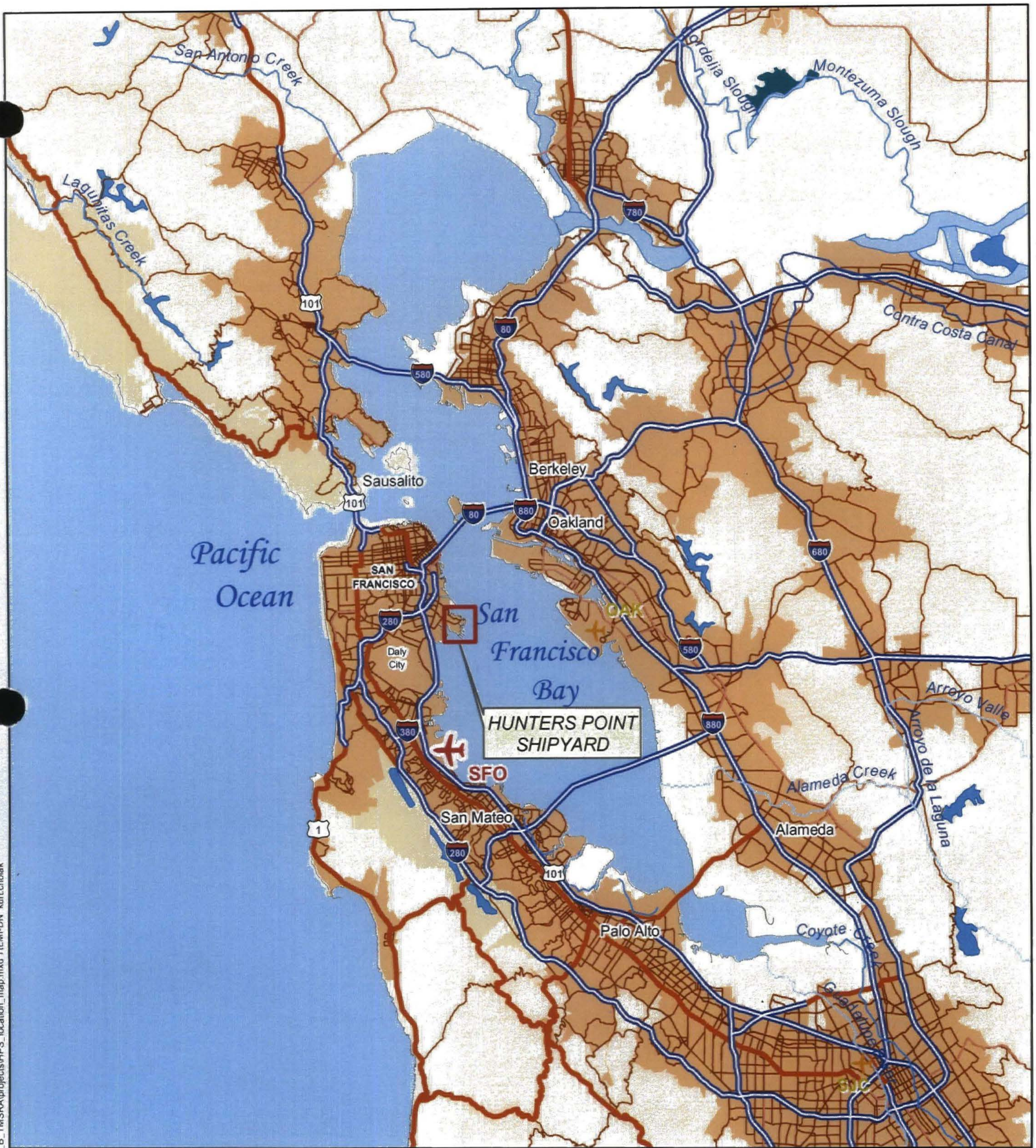
- **Appendix I – Trigger Levels for Groundwater Impacts to San Francisco Bay** evaluates groundwater at Parcel B to assess potential affects of groundwater on the bay and develops trigger levels for protection of the bay.

- **Appendix J – Metals Concentrations in Franciscan Bedrock Outcrops Study** contains the draft report prepared to summarize the investigation of ambient concentrations of metals in bedrock and bedrock-derived soil from three nonindustrial sites in San Francisco conducted by the Navy in 2003.

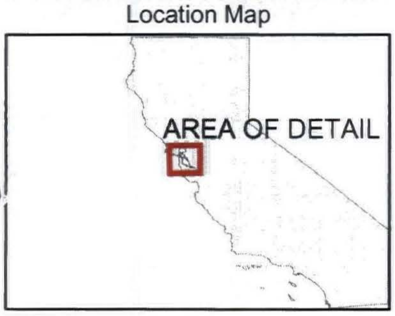
- **Appendix K – Responses to Regulatory Agency Comments on the Draft TMSRA** presents the Navy's responses to comments received on the draft report submitted in March 2006.

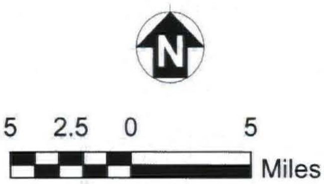
- **Appendix L – Responses to Regulatory Agency Comments on the Draft Final TMSRA** presents the Navy's responses to comments received on the draft final report submitted in June 2007.

FIGURES



Location Map





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Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-1
HUNTERS POINT LOCATION MAP

TMSRA for Parcel B

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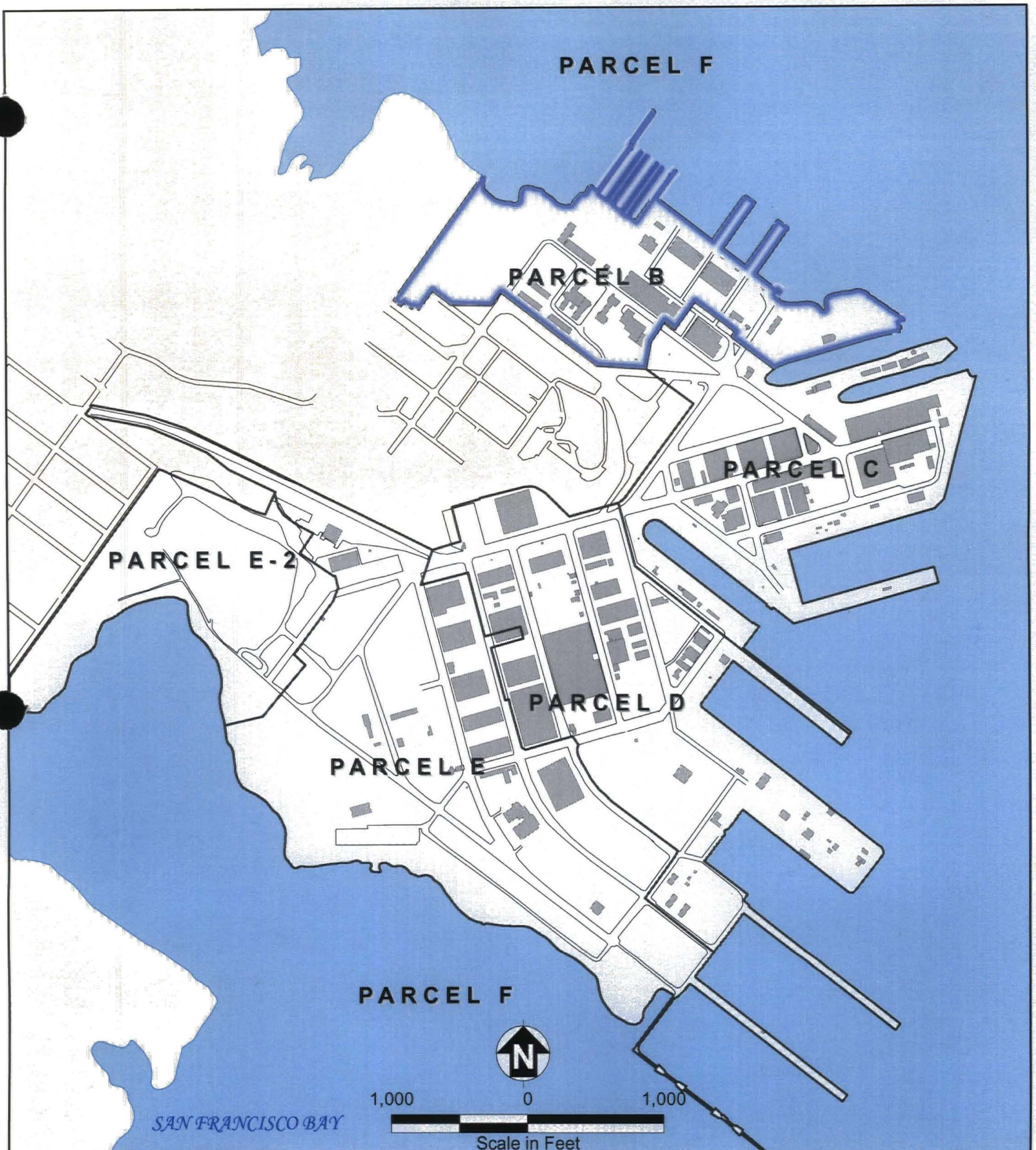

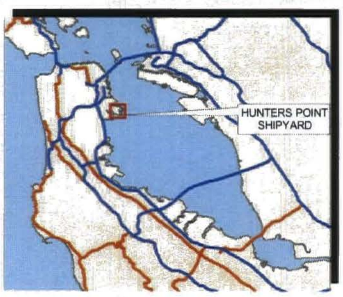

Location Map

Parcel B Boundary
Parcel Boundary
Building
Non-Navy Property
Road

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Consulting Engineers and Scientists

Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 1-2
FACILITY LOCATION MAP

TMSRA for Parcel B

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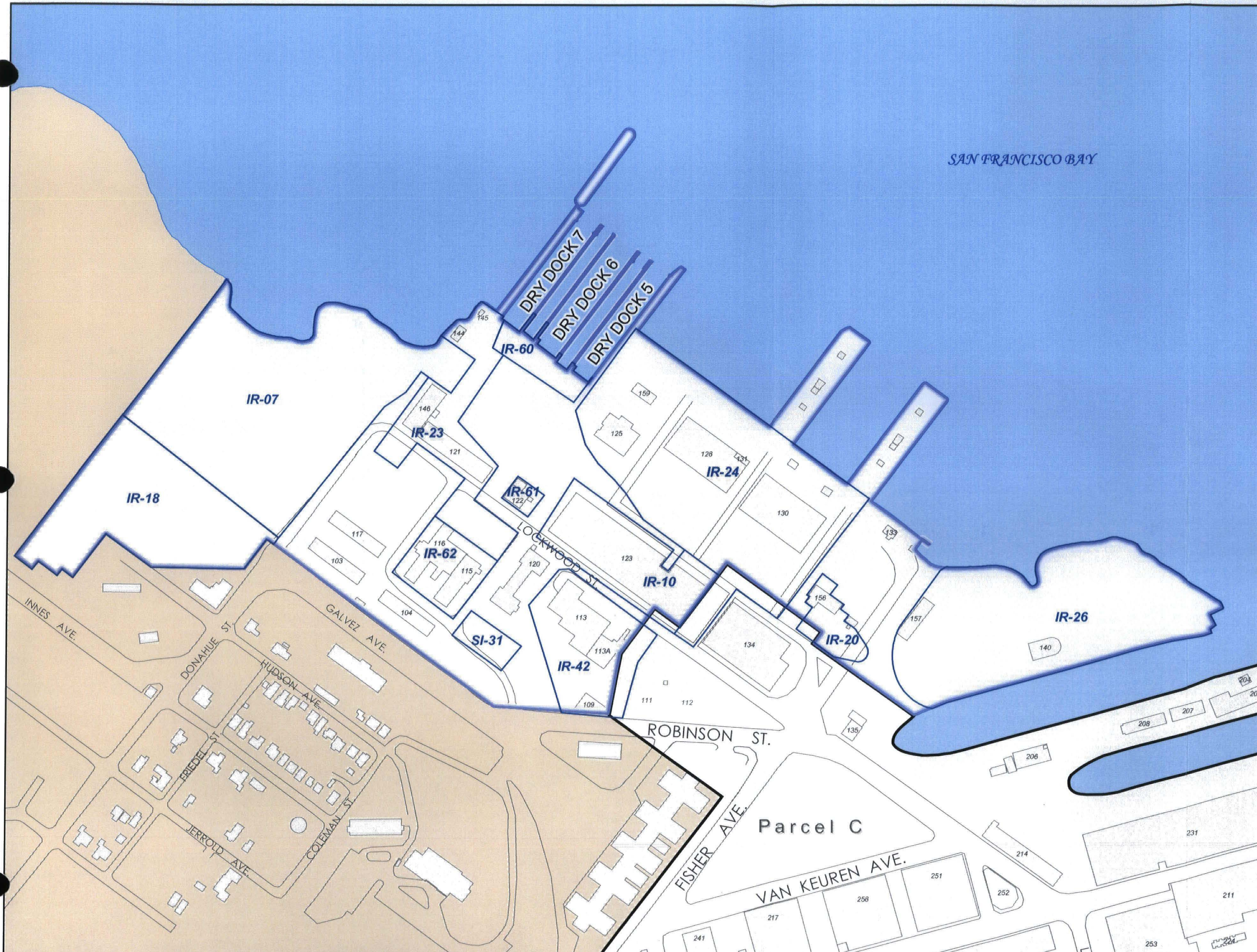

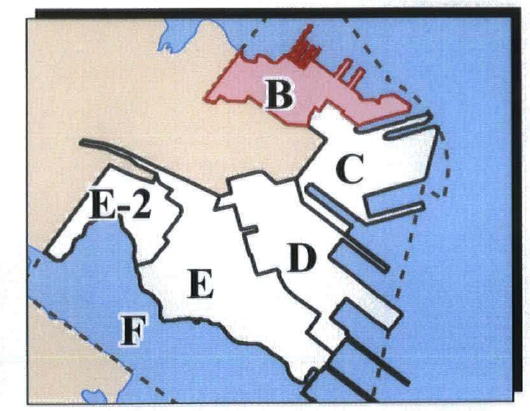

Location Map

Road
IR or SI Site
Parcel B Boundary
Other Parcel Boundary
128 Building
Non-Navy Property
San Francisco Bay

Notes:
IR Installation Restoration
SI Site Inspection

0 300 600
Scale in Feet

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FIGURE 1-3
INSTALLATION RESTORATION AND SITE INSPECTION SITES

TMSRA for Parcel B

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PARTIALLY SCANNED OVERSIZE ITEM(S)

See document # 2259642

for partially scanned image(s).

FIGURE 1-4

(1 OF 5)

For complete hardcopy version of the oversize document contact the Region IX Superfund Records Center

TABLES

Table 1-1: CERCLA Chronology for Parcel B

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

CERCLA Process Step	Document	Date Completed
Preliminary Assessment/Site Inspection	Site Inspection Report	April 1994
Remedial Investigation	Remedial Investigation Report	June 1996
Feasibility Study	Feasibility Study Report	November 1996
Proposed Plan	Proposed Plan	October 1996
Record of Decision	ROD	October 1997
Explanation of Significant Differences	Explanation of Significant Differences (first)	August 1998
Remedial Design	Remedial Design Documents	August 1999
Remedial Action (Phase I)	Field Excavations	July 1998 to September 1999
Explanation of Significant Differences	Explanation of Significant Differences (second)	May 2000
Remedial Design Amendment	Remedial Design Amendment	February 2001
Remedial Action (Phase II)	Field Excavations	July 2000 to December 2001
Remedial Action (report)	Construction Summary Report	November 2002
	Construction Summary Report Addendum	September 2004
Five-Year Review	First Five-Year Review of Remedial Actions Implemented at Hunters Point Shipyard (focus was Parcel B)	December 2003
TMSRA (update to Feasibility Study)	Technical Memorandum in Support of a ROD Amendment	December 2007
Proposed Plan in Support of a ROD Amendment	Proposed Plan	April 2008
ROD Amendment	ROD Amendment	October 2008
Remedial Design	Remedial Design	April 2009
Remedial Action	Field Actions and Report	July 2011

Notes:

CERCLA Comprehensive Environmental Response, Compensation, and Liability Act
ROD Record of decision
TMSRA Technical memorandum in support of a record of decision amendment

2.0 PARCEL B ACTIVITIES SINCE THE ROD

The Navy has conducted a series of activities since the ROD was signed in October 1997. This section presents a summary of Navy actions since the ROD and updates to the site conceptual models for soil and groundwater that have resulted from the new information gained during these actions. This section does not repeat information about aspects of Parcel B that have not changed since the ROD. The reader is referred to the FS report (PRC Environmental Management, Inc. [PRC] 1996) for discussions of the history of HPS and Parcel B and basic site characteristics such as climate, topography, and surface water hydrology.

2.1 ACTIONS SINCE ROD

Activities since the October 1997 ROD include changes to the boundary of Parcel B, additional investigations, removal and remedial actions, treatability studies, and regulatory actions. Table 2-1 lists documents that summarize the post-ROD activities according to broad categories related to the soil remedy, groundwater remedy, treatability studies, or regulatory actions.

2.1.1 Changes in Parcel B Boundary

The boundary of Parcel B has changed twice since the October 1997 ROD. The first change affected the southeastern boundary with Parcel C. The Navy discovered VOCs in soil and groundwater at Excavation A-1 during 2001. The source of these VOCs appeared to be related to activities in nearby Building 134. Consequently, the Navy revised the boundary between Parcels B and C to consolidate the area subject to similar contamination and potential remedial action and include the area as part of Parcel C. This change resulted in IR-06 moving to Parcel C. The Navy documented the change in the boundary in a memorandum to the administrative record file on February 1, 2002 (Navy 2002). This change is consistent with the boundary adjustment that was implemented during the comment period on the original Parcel B proposed plan and ROD. (The adjustment made at the time of the original ROD moved the boundary between Parcels B and C to incorporate Building 134 [and IR-25] within Parcel C.) The adjustment of the parcel boundary to move IR-06 to Parcel C reduced the area of Parcel B from 63 to 59 acres.

The second change affected the southeastern boundary with the former Parcel A. Minor adjustments in the boundary in this area were made to ensure that soil contamination related to activities in Parcel B was contained within the boundary of Parcel B. Soil contamination discovered in 2001 at Excavation B0146 originally overlapped into the former Parcel A, and this boundary change allowed all the contamination to be contained within Parcel B. The Navy documented this boundary adjustment in the finding of suitability to transfer documents for Parcel A (Tetra Tech EM Inc. [Tetra Tech] 2004). The adjustment involved only a small fraction of an acre, and the area of Parcel B remained about 59 acres.

2.1.2 History of Investigations

This section discusses investigations the Navy has conducted at Parcel B since the October 1997 ROD. Additional investigation also occurred during remedial actions as well as during treatability studies, and these activities are discussed separately in the succeeding sections. The resulting changes to the conceptual model for soil and groundwater contamination at Parcel B are discussed in Section 2.2.

Investigations at Parcel B since the 1997 ROD include the Historical Radiological Assessment, an investigation of the Bay Mud Aquitard and B-aquifer, a study of fill conditions at IR-07 and IR-18, an investigation into sediment contamination along the Parcel B shoreline, studies of ambient concentrations of nickel and manganese in soil, a soil gas investigation at IR-07 and IR-18, and an investigation of VOCs in groundwater at the boundary of Parcels B and C.

Historical Radiological Assessment. The Historical Radiological Assessment evaluated potential radiological contamination from maintenance of nuclear-powered ships (Radiological Affairs Support Office 2000) and from use of general radioactive materials at HPS (Radiological Affairs Support Office 2004). The Historical Radiological Assessment identifies radiologically impacted areas at Parcel B. The term "radiologically impacted" is defined in the Historical Radiological Assessment as "an area, building, or piece of equipment that, under professional interpretation, has the distinct possibility of having residual radioactive material associated with it." Table 2-2 presents a list of radiologically impacted areas at Parcel B summarized from the Historical Radiological Assessment. Figure 2-1 shows the locations of the radiologically impacted areas at Parcel B. The Navy continues to investigate and clean up radiologically impacted areas throughout HPS, including some at Parcel B, under the authority of the Basewide Radiological Removal Action Memorandum (Navy 2000b). Potential remedial actions in the TMSRA that would involve excavation and disposal account for screening for radiological contamination in the areas identified as impacted.

Distribution of Bay Mud Aquitard and B-Aquifer Characterization. The Navy investigated the thickness and extent of the Bay Mud, which acts as an aquitard that separates the A- and B-aquifers, and characterized groundwater in the B-aquifer at Parcel B (Tetra Tech 2001b). The Navy drilled four soil borings, installed two groundwater monitoring wells, and collected soil and groundwater samples during the investigation. The study found that the Bay Mud Aquitard separates the A- and B-aquifers or that the B-aquifer is absent in most of Parcel B. However, the A-aquifer directly overlies the B-aquifer in some areas, notably in the western portion of Parcel B in IR-18. For example, samples collected from boring IR18MW101B demonstrated that the Bay Mud Aquitard was absent at that location. Although observational evidence indicates a potential connection between the A- and B-aquifers in IR-18, chemical results do not indicate a direct hydraulic connection. Neither soil samples nor groundwater samples collected in the B-aquifer in IR-18 exceeded any of the screening criteria used during the study. Lithologic results from the study are incorporated into the updated site conceptual model (see Section 2.2), and analytical results are included in the HHRA, which is Appendix A of this report.

Fill Conditions Study at IR-07 and IR-18. The Navy studied the nature and extent of the debris fill at IR-07 and IR-18 to delineate further the types and distribution of debris materials observed during remedial action excavations at these IR sites (Tetra Tech 2003a). The study included a review of historical documents such as aerial photographs and soil boring logs and a geophysical investigation using conductivity and magnetometer surveys. The study documented the progressive filling of San Francisco Bay in the area of IR-07 and IR-18 from 1948 to 1972 and noted widespread distribution of low-quality fill with a high debris content. Debris included wood, asphalt, concrete, brick, metal, and other demolition-type debris, as well as sandblast grit from HPS operations. The study concluded that fill conditions at IR-07 and IR-18 vary greatly from the rest of Parcel B. Potential remedial actions considered for IR-07 and IR-18 in the TMSRA account for the unique subsurface conditions in this area.

Shoreline Sediment Investigation. The Navy investigated the nature and extent of chemicals in sediments along the shoreline at IR-07 and IR-26 (Tetra Tech and Innovative Technical Solutions, Inc. [ITSI] 2004b). The investigation included collection of 67 samples from 23 locations along the shoreline of IR-07 (20 locations) and IR-26 (3 locations). Sample locations were distributed in a systematic (grid) pattern. Samples were collected from the surface to 4 feet below surface. Many samples at IR-26 were not collected because riprap interfered with sample collection (that is, no sediment was present). Sediment samples collected during this investigation are further evaluated in the SLERA, which is Appendix B of this report.

Nickel and Manganese in Soil Study. The Navy studied nickel and manganese to evaluate further the nature of background concentrations of these metals in HPS soils. Ambient concentrations of a broad group of metals are summarized as Hunters Point ambient levels (HPAL) (PRC 1995). However, the unique geology at HPS, especially the presence of rock types such as serpentinite, basalt, and chert, results in naturally higher concentrations of nickel and manganese. The Navy studied the distribution of nickel concentrations in soil across HPS and found a positive correlation among concentrations of nickel, magnesium, and cobalt. These correlations were quantified as regression equations for (1) nickel versus magnesium, and (2) nickel versus cobalt, and these regression equations replaced a single, numerical value for the HPAL for nickel (Tetra Tech 1999). The Navy also studied the distribution of manganese in soil across HPS (Tetra Tech 2001e, 2001f, 2001h). The Navy agreed to continue to use the original HPAL for manganese (1,431 milligrams per kilogram [mg/kg]). HPALs, including the regression equations for the HPAL for nickel, are considered during the human health risk assessment in the TMSRA (see Section 3.0).

Metals Concentrations in Franciscan Bedrock Outcrops Study. The Navy studied the ambient concentrations of metals in bedrock and bedrock-derived soil from three nonindustrial sites in San Francisco (Tetra Tech and ITSI 2004a). The geologic setting of these three sites is similar to HPS and contains serpentinite or chert and basalt bedrock typical of the Franciscan Complex. The sites included two Franciscan Complex subunits: the Hunters Point Shear Zone and the Marin Headlands Terrane. The investigation included about 30 rock and soil samples from each of the three sites (91 samples total) that were analyzed for metals using a standard analytical suite of EPA methods. The study found elevated concentrations of arsenic, iron, and manganese associated with chert bedrock and elevated nickel concentrations associated with serpentinite. The chemical composition of soil at the three sites was found to be similar to the chemical composition of rock. Of the 91 samples collected, none met the cleanup standards for unrestricted residential reuse at HPS. Appendix J contains the report from this investigation.

Soil Gas Investigation at IR-07 and IR-18. The Navy investigated IR-07 and IR-18 to evaluate whether the fill is producing methane and other VOCs (SES-TECH 2005). The study consisted of active soil gas measurements at more than 50 locations on a grid across the IR-07 and IR-18 areas. The study found one area in the eastern portion of IR-07 where concentrations of methane and VOCs exceeded 5 percent methane (by volume in air) or 1,000 parts per million by volume VOCs. This area is scheduled for further characterization to investigate the source of the methane and VOCs in soil gas. Remedial alternatives in the TMSRA consider options to address the findings of the investigation.

VOCs in Groundwater Investigation at the Boundary of Parcels B and C. The Navy investigated the area near Building 134 along the boundary between Parcels B and C to further delineate the extent of VOC contamination in groundwater in the A-aquifer (CE2 Corporation [CE2] 2005). This VOC-contaminated area in Parcel C is termed remedial unit (RU)-C5. The investigation was conducted in phases that involved collecting active and passive soil gas samples, collecting groundwater samples using direct-push techniques, and collecting groundwater samples from existing monitoring wells. Field activities for this investigation were completed in March 2006 and a final investigation summary report was submitted in November 2006 (CE2 2006). The investigation found (1) that dissolved-phase VOCs in groundwater in the shallow A-aquifer have migrated from Parcel C to Parcel B, but concentrations at Parcel B were below maximum contaminant levels (MCL), (2) that there was no indication of dense nonaqueous-phase liquids (DNAPL) in the aquifer at Parcel B, and (3) that there was no evidence for migration of DNAPLs onto Parcel B from Parcel C.

2.1.3 History of Removal and Remedial Actions

The 1997 ROD identified soil excavation and disposal and groundwater monitoring as major components of the remedy for Parcel B (Navy 1997). The following sections discuss these remedial actions and other, related removal actions by medium.

2.1.3.1 History of Soil Actions

The 1997 ROD identified excavation of contaminated soil, off-site disposal, and placement of clean backfill as the primary components of the selected remedy. The Navy conducted a series of excavations at Parcel B to remove contaminated soil, including (1) pre-ROD exploratory excavations in 1996, (2) remedial action excavations in 1998 to 2001, and (3) a removal action to excavate soil contaminated by fuel-related compounds in 2004. Figure 2-2 shows the locations of these previous excavations at Parcel B; additional details about the excavations are provided below.

Exploratory Excavations. The Navy conducted exploratory excavations at 18 sites across HPS between July 1996 and January 1997 (IT Corporation [IT Corp.] 1999). These excavations included removal actions at five sites at Parcel B. The volume of the excavations was limited during this initial, exploratory phase. A total of approximately 1,700 cubic yards of soil was removed from the five sites at Parcel B.

Remedial Actions. The Navy conducted remedial actions for soil in two phases: 1998 to 1999, and 2000 to 2001. The Navy excavated about 54,400 cubic yards of soil from 84 areas at Parcel B between July 1998 and September 1999. The RD (Tetra Tech and Morrison Knudsen Corporation 1999a) for this phase included confirmation sampling after an excavation had been completed. However, the excavations failed to remove contaminants to below cleanup goals for soil in many excavations, and the soil remedial action paused in September 1999 while the Navy reevaluated the cleanup goals presented in the 1997 ROD (see Section 2.1.5 for more discussion). The Navy summarized revised cleanup goals in the May 2000 explanation of significant differences (ESD) (Navy 2000a). Between May 2000 and December 2001, the Navy excavated and disposed of off site approximately 47,200 cubic yards of soil from 43 areas, some of which had been originally excavated during 1998 to 1999. This second phase of excavation followed an amended RD that included pre-excavation sampling to delineate excavation areas (Tetra Tech 2001c). During the second phase, new excavation areas were opened, and some excavations begun in 1998 to 1999 were reopened. Similar to the first phase, the second phase of excavations did not remove all contaminants to below cleanup levels for soil, and the remedial action was halted for reevaluation. The Navy excavated a total of 101,600 cubic yards of soil from 106 areas at Parcel B during both phases, compared with the estimate of 38,000 cubic yards at 85 areas in the 1997 ROD. Details of the remedial action excavations are presented in the construction summary report (Tetra Tech 2002a) and an addendum (SulTech 2004). This TMSRA represents the next step in the CERCLA process to address the chemical concentrations that remain in soil.

Excavations to Remove Fuel-Related Contamination. The Navy removed about 29,000 cubic yards of soil from 12 excavations at sites across HPS between July 2004 and January 2005 to remove soil that was contaminated by fuel-related products (TPA-CKY Joint Venture 2005). The Navy removed and disposed off site about 9,800 cubic yards of soil from two areas at Parcel B during this action.

2.1.3.2 History of Groundwater Actions

The 1997 ROD identified groundwater monitoring, lining storm drains, and removing steam and fuel lines as primary components of the selected remedy. The Navy developed the remedial action monitoring program (RAMP) to describe the groundwater monitoring program for Parcel B. The Navy investigated storm drains as potential conduits for groundwater migration and excavated steam and fuel lines. In addition, the Navy investigated the extent of chromium VI in groundwater at IR-10 during implementation of the RAMP. The following sections present details of the RAMP and these related removals and investigations.

Remedial Action Monitoring Program. The Navy prepared the RAMP (Tetra Tech and Morrison Knudsen Corporation 1999b) as part of the RD in 1999. In accordance with the requirements of the 1997 ROD, the RAMP established monitoring locations (1) along the point of compliance (POC), which was defined as the high-tide line of the tidally influenced zone, and (2) at positions upgradient from the POC that represent the approximate distance groundwater would travel in 5 years. The wells upgradient from the POC were termed sentinel wells. The RAMP originally identified 24 wells for groundwater monitoring grouped into the following six categories:

1. POC wells at the high-tide line of the tidally influenced zone (eight wells)
2. Sentinel wells set back from the POC by a buffer zone (seven wells)
3. Post remedial action wells downgradient from excavations at IR-07 (five wells)
4. VOC monitoring well near the chlorinated solvent plume at Building 123 in IR-10 (one well)
5. On- and off-site migration wells at the western boundary of HPS (two wells)
6. A utility line well in IR-06 near the former tank farm behind Building 134 (now in Parcel C) (one well)

In addition to the original RAMP wells described above, the Navy incorporated other wells into the RAMP during the course of the monitoring program: (1) additional wells in and around the IR-10 VOC plume, (2) supplemental characterization wells near Excavation EE-05 in IR-26, and (3) a well (IR10MW12A) to monitor chromium VI, based on historical sampling results. All wells are sampled quarterly except for the sentinel wells, which are sampled semiannually. The Navy currently monitors 39 wells in the RAMP and has collected samples for 32 quarters as of December 2007; quarterly monitoring continues under the RAMP. Figure 2-3 shows the locations of RAMP wells. Table 2-3 summarizes the results of the RAMP; records are discontinuous for five wells (IR07MWS-4, IR07MW21A1, IR07MW24A, IR07MW25A, and IR07MW26A) at IR-07 because these wells were decommissioned during remedial excavations and were later reinstalled. Table 2-3 identifies chemicals that exceeded RAMP criteria through March 2007 (quarter 29). Table 2-3 is intended to provide an overview of the results of the RAMP; please refer to the individual quarterly reports for details such as detection limits and specific issues that might affect groundwater data quality for any individual sampling event. The analytical data from the quarter 21 through 29 events are not included in the database in Appendix F or in the HHRA or SLERA. The monitoring results have shown that most metals detected above the RAMP criteria are sporadic, with the exception of chromium VI at well IR10MW12A and mercury at wells IR26MW47A and IR26MW49A, which have been consistently detected. The monitoring results also indicate successful remediation in parts of the IR-10 VOC plume (for example, well IR10MW59A) as the result of the ZVI injection treatability study (also see Section 2.1.4).

Chromium VI Delineation Study. The Navy installed 10 temporary monitoring wells in the A-aquifer in 2002 at locations down-, cross-, and up-gradient from well IR10MW12A to monitor concentrations of chromium VI in groundwater in the area of this well. These wells were installed inside Building 123 near potential sources and outside the building near the utility and storm drain lines to identify the sources of chromium VI, delineate the extent of chromium VI in groundwater, and evaluate site conditions. Borings for these wells extended to 12 to 15 feet bgs and the wells characterized the full extent of the A-aquifer in the area around well IR10MW12A. In addition, borings for these wells found clay beneath the A-aquifer. The study concluded that downward migration of chromium VI was unlikely based on the low hydraulic conductivity of the clay, the large available surface area for adsorption, and the high potential for reduction of chromium VI to chromium III by organic material, iron, and manganese contained in the clay. The study found the extent of chromium VI was limited to the immediate area around well IR10MW12A. Appendix H contains the report from this investigation.

Storm Drain Infiltration Studies. The Navy studied potential infiltration of groundwater into storm drain lines at Parcel B in October 1997 (Tetra Tech 1998). After review and comments by the BCT, the Navy conducted a focused investigation of two reaches of the storm drain in Parcel B between April 1999 and November 2000 (Tetra Tech 2001d). The two reaches investigated were storm water Basins 2 and 4; both were below the groundwater table and intersected contaminant plumes (as mapped at that time). Basin 2 is located in eastern IR-07 north of Building 146; Basin 4 is located in eastern IR-24 roughly between Buildings 134 and 130. The focused investigation included (1) isolating and videotaping reaches to identify areas of infiltration and sampling storm water, (2) excavating 13 test pits and using direct-push borings to investigate the soil texture and permeability of pipeline backfill materials, and (3) conducting follow-up inspections. The study found groundwater was infiltrating into the storm drain line at Basin 2, but no contamination was present in groundwater in that area. No groundwater infiltration was observed at Basin 4. The study also found that the soil texture and permeability of backfill materials were not significantly different from the surrounding fill. Overall, the study recommended no further action be taken related to the storm drains, except for continued monitoring of a group of RAMP wells.

Groundwater Evaluation Technical Memorandum. After 2 years of groundwater monitoring under the RAMP, the Navy prepared a technical memorandum (Tetra Tech 2001g) to reevaluate the monitoring program based on the groundwater data collected by the RAMP and earlier investigations. The objective of the technical memorandum was to support development of a revised RAMP. In the technical memorandum, data were evaluated with respect to temporal trends, spatial distribution, ambient sources, anthropogenic sources, and proximity to soil removal areas. The technical memorandum recommended revisions to the RAMP including:

- Discontinue groundwater monitoring in western Parcel B
- Monitor well IR10MW12A quarterly for chromium VI
- Monitor five wells near well IR10MW59A quarterly for trichloroethene and vinyl chloride
- Install three new wells at IR-26 and sample quarterly (these were wells IR26MW46A, IR26MW47A, and IR26MW48A installed in January 2002)
- Reevaluate further sampling after 1 year of monitoring was completed to further optimize the RAMP

The Navy and the BCT discussed the recommendations in the technical memorandum but did not reach agreement on modifications to the RAMP. The technical memorandum was not finalized and, although wells were added to the RAMP, the RAMP document was not changed.

2.1.4 History of Treatability Studies

The Navy conducted treatability studies at IR-10 using SVE and injection of ZVI to evaluate the effectiveness of these techniques to clean up VOCs in soil and groundwater located beneath the northwestern portion of Building 123. The Navy also conducted a treatability study using sequential anaerobic and aerobic bioremediation at nearby Building 134 in Parcel C for similar contaminants (VOCs) in groundwater. The following sections briefly describe these studies.

Soil Vapor Extraction. The Navy tested a pilot-scale SVE system at Building 123 in IR-10 between December 2000 and June 2001 (IT Corp. 2002). The test used a trailer-mounted blower system and granular activated carbon for off-gas cleanup. It incorporated 14 SVE wells and nine vapor monitoring well pairs installed in the vadose zone to a maximum depth of about 10 feet bgs. Testing showed significant removal of VOCs, although VOC concentrations rebounded after the SVE system was shut down. The Navy confirmed the effectiveness of the pilot test by collecting 44 soil samples from 22 soil borings in the treatment area during September 2002 (Tetra Tech 2003c). Analysis of these soil samples indicated that VOC concentrations were reduced about 80 percent during test operations.

The Navy expanded the pilot-scale SVE system at Building 123 during January through May 2005 by installing 24 soil gas probes, nine SVE wells, and six vapor monitoring well pairs (ITSI 2006). The SVE system operated from June 15 through September 13, 2005 when the system was shut down for rebound monitoring. Monitoring for rebound continued through December 15, 2005. The SVE system operated again from January 3 to January 11, 2006 when operations ended.

Vapor monitoring using a photoionization detector indicated that VOCs were reduced to below detection levels in 22 of 23 SVE wells and 27 of 28 vapor monitoring wells. VOC concentrations rebounded (to varying degrees) in 14 of the 23 SVE wells. The treatability study report recommended that the system be expanded to include additional vapor extraction wells and operated to remove additional VOCs. The system remains in place in the event it is used during future remedial action.

Zero-Valent Iron Injection. The Navy evaluated the effectiveness of ZVI as a means to clean up chlorinated VOCs in groundwater at IR-10. The Navy conducted a pilot test using ZVI at Building 123 between September 2003 and March 2004 (Engineering/Remediation Resources Group, Inc. [ERRG] and URS Corporation [URS] 2004). The test included injection of a slurry of about 130,500 pounds of ZVI powder into 37 boreholes distributed over an area of about 16,000 square feet. The test used hydraulic pressure to inject a slurry of water and ZVI into the A-aquifer to a maximum depth of 28 feet bgs. The ZVI effectively established reducing conditions in the aquifer and promoted breakdown of the chlorinated VOCs. Results from groundwater monitoring indicated about a 50 percent reduction in the mean concentration of trichloroethene. In some individual wells, trichloroethene concentrations dropped from hundreds of milligrams per liter to below detection limits. Monitoring the groundwater in the test area continues quarterly under the RAMP.

Sequential Anaerobic and Aerobic Bioremediation. The Navy tested a pilot-scale system for sequential anaerobic and aerobic bioremediation at Building 134 in Parcel C from April 2004 through June 2005 (Shaw Environmental, Inc. 2005). The anaerobic stage of the test continued through December 2004 and included injection of lactate and hydrogen to stimulate biological breakdown of chlorinated solvents in groundwater in the A-aquifer. Fairly rapid reductive dechlorination of the chlorinated ethenes was observed in three monitoring wells, as indicated by the sequential transformation of tetrachloroethene to trichloroethene to dichloroethene to vinyl chloride to ethene. The data indicate that the indigenous organisms are capable of complete degradation of the chlorinated ethenes to non-toxic ethene. Although the test was not conducted on Parcel B, the subsurface conditions at Building 134 (in terms of hydrogeology and the chemicals present in groundwater) are sufficiently similar to make the test results useful for consideration for groundwater at Parcel B.

2.1.5 History of Regulatory Actions

This section briefly describes the 1997 ROD and the two subsequent ESDs that apply to Parcel B. This section also summarizes the first five-year review for HPS, which focused on Parcel B.

2.1.5.1 October 1997 ROD

The Navy and the regulatory agencies signed the ROD for Parcel B, dated October 7, 1997, on October 9, 1997 (Navy 1997). The ROD addresses both soil and groundwater contaminated by CERCLA hazardous substances at Parcel B. The ROD also addresses remediation of areas where CERCLA hazardous substances are commingled with petroleum hydrocarbons. Areas that contained only petroleum hydrocarbons, which are not hazardous substances as defined by CERCLA, are addressed in a separate petroleum hydrocarbon corrective action plan under the oversight of the Water Board (Tetra Tech 2001a).

The Navy selected excavation and off-site disposal as the remedy for contaminated soil at Parcel B. The major components of the soil portion of the remedy, as described in the ROD, include:

- Excavation of contaminated soil to the groundwater table or 10^{-6} cancer risk (residential) (later modified by the ESD; see below).
- Off-site disposal of contaminated soil (with treatment at the off-site landfill, if necessary to meet land disposal restrictions).
- Placement of clean backfill in the excavated areas.

- Deed notification indicating that soil below the groundwater table in remediated areas may be contaminated.

- Institutional controls governing the handling of residual contaminated soil.

The Navy selected groundwater monitoring, lining of storm drains, and removal of steam and fuel lines as primary components of the selected remedy. The major components of the groundwater portion of the remedy, as described in the ROD, include:

- Lining the storm drains and pressure grouting of the bedding material in the storm drains at IR-07 and IR-10 in those locations where the storm drain system is below the groundwater table in an affected groundwater area.

- Removal of steam and fuel lines.

- Deed restrictions on Parcel B, such as prohibiting all uses of groundwater within the shallow water-bearing zone(s) to 90 feet bgs.

- Groundwater monitoring for up to 30 years to evaluate the effectiveness of the removal actions for soil and to monitor concentrations of hazardous substances that may migrate toward San Francisco Bay. Groundwater monitoring at IR-10 to monitor for the future potential degradation of trichloroethene to vinyl chloride.

- Deed notification indicating that contamination may be present in groundwater in the remediated areas and that surface discharge of contaminated groundwater is prohibited.

Two subsequent changes were made to the soil portion of the selected remedy in the October 1997 ROD for Parcel B. These changes are described in the ESDs dated August 24, 1998, and May 4, 2000.

2.1.5.2 August 1998 ESD

The first ESD to the Parcel B ROD was dated August 24, 1998, and was signed by the Navy and the regulatory agencies on October 28, 1998 (Navy 1998).

The selected remedy for contaminated soils in the Parcel B ROD was excavation to the groundwater table followed by off-site disposal. When the ROD was prepared, groundwater was believed to occur typically at 10 feet bgs. However, in early 1998, measurements at the site indicated that the depth to groundwater beneath Parcel B could be as shallow as 2.3 feet bgs. Future construction workers would not be protected if falling groundwater levels allowed residual contaminated soils, previously believed to be remediated, to be exposed. The August 1998 ESD therefore revised the selected remedy to require excavation of contaminated soils to a 10^{-6} cancer risk (residential) or to a maximum depth of 10 feet bgs, instead of to the groundwater table, to ensure that the remedy is protective of human health in both the short and long term.

2.1.5.3 May 2000 ESD

The second ESD to the Parcel B ROD was dated May 4, 2000, and was signed by the Navy and the regulatory agencies on May 9, 2000 (Navy 2000a).

The May 2000 ESD updated the cleanup goals for soil presented in Table 8 of the Parcel B ROD to incorporate (1) EPA's 1999 preliminary remediation goals (PRG), including adjustments by the Navy to incorporate the produce uptake pathway, and (2) revised ambient levels for nickel. The basis for these changes is presented below.

Change in EPA PRGs. When the cleanup levels presented in Table 8 of the ROD were developed in 1995, they were consistent with EPA and state guidance for human health risk assessment. Specifically, the cleanup levels correspond to:

- A human health risk level of 10^{-6} (one in one million) or less for carcinogens, except where ambient levels exceed 10^{-6}.
- A hazard index (HI) of 1 or less for noncarcinogens, except where ambient levels exceed an HI of 1 because of fill material.
- Lead levels of less than 221 mg/kg.

The cleanup levels assume residential contact with soils, including consumption of homegrown produce. Since 1995, EPA has updated the guidance for risk assessment input parameters for several classes of chemicals. Applying the revised guidance (1999 PRGs adjusted to incorporate the produce update pathway, as appropriate) resulted in revised chemical-specific cleanup levels. Attachment A to the May 2000 ESD presented the original and revised cleanup values.

Change in Ambient Values for Nickel. Nickel concentrations in soil samples collected from remediation areas excavated in the early phases of the remedial action in 1998 often exceeded the cleanup goal for soil based on the HPAL. The HPAL for nickel used in the 1997 ROD was based on a regression equation for nickel versus magnesium. The Navy reviewed the approach used to calculate the HPAL for nickel and, with support from DTSC, formulated a nickel-cobalt regression equation to more accurately calculate the ambient levels of nickel. This approach was presented in the nickel screening and implementation plan technical memorandum dated August 4, 1999 (Tetra Tech 1999). The May 2000 ESD incorporated the nickel-cobalt regression equation for calculating the cleanup goal for nickel in soil at each sample location (Navy 2000a).

2.1.5.4 First Five-Year Review

The Navy summarized the first five-year review for HPS in a report dated December 10, 2003 (Tetra Tech 2003d). The five-year review encompassed all of HPS but focused on Parcel B because remedial actions had not been implemented yet at the other parcels at HPS.

The purpose of the five-year review was to evaluate the implementation and performance of the remedy and to assess whether the remedy is or will be protective of human health and the environment. The report presented a protectiveness determination, identified issues found during the review, and made recommendations to address them.

Protectiveness Statement for Soil. The soil remedy at Parcel B is currently protective of human health and the environment because exposure pathways that could result in unacceptable risks are being controlled through extensive soil excavation and the use of fencing, locked gates, warning signs, and secured buildings that limit access to remaining contaminated areas. New information became available after the remedial action was implemented, which indicates that, for the soil remedy to be protective in the long-term, the HHRA needs to be updated using new toxicological data and methodologies, potential ecological risks to aquatic receptors should be evaluated, and the selected remedy needs to be modified to address remaining areas of contamination. A ROD amendment is planned to ensure that the final soil remedy implemented at Parcel B will be protective of human health and the environment in the long-term.

Recommendations and Follow-up Actions for Soil. The five-year review identified the following actions related to the soil remedy. Each bullet also indicates how these items are addressed in the TMSRA.

- Subsurface conditions need to be further evaluated at IR-07 and IR-18, the conceptual model needs to be updated, and a site-specific approach should be developed as part of the Parcel B ROD amendment process. The TMSRA addresses the debris fill area at IR-07 and IR-18 (Redevelopment Blocks 2, 3, and BOS-1).

- Potential need for remedial action at the shoreline near IR-07 and IR-26 should be evaluated during the ROD amendment process. The alternatives in the TMSRA include remediation of the shoreline at IR-07 and IR-26 (Redevelopment Blocks BOS-1 and BOS-3).

- Potential ecological risk to aquatic receptors from Parcel B contaminants should be evaluated. The TMSRA contains an evaluation of potential risk to ecological receptors along the shoreline.

- Effectiveness of the SVE system at IR-10 should be further evaluated during the ROD amendment process and included in an amended ROD if SVE is selected as a remedy for VOC-contaminated soil. If SVE is not selected as the remedy, remaining portions of IR-10 that have not been excavated will need to be addressed. The TMSRA contains remediation alternatives that include SVE for VOCs in soil at IR-10 (Redevelopment Block 8). The TMSRA also contains remediation alternatives to address metals concentrations that exist in soil in the same area at IR-10; these metals would not be treated by the SVE system. Metals will be addressed by ensuring that the exposure pathway is broken by a cover consistent with the rest of Parcel B.

- Soil RAOs and remedial action alternatives should be reevaluated during the ROD amendment process to address higher and more variable levels of ambient metals. The RAOs in the TMSRA account for higher and more variable levels of ambient metals.

- The HHRA should be updated with new toxicological data and calculate cumulative risk as part of the ROD amendment process. The updated HHRA in the TMSRA incorporates new toxicological data and provides information about total risk.

- Enforceable land-use restrictions need to be developed before the remedy is complete. The TMSRA contains more detailed information on potential institutional controls.

Protectiveness Statement for Groundwater. The groundwater remedy at Parcel B is currently protective of human health and the environment because the RAMP safeguards aquatic life in the bay and addresses potential risk to future occupants of Parcel B buildings. New information became available after the remedial action was implemented, which indicates that, for the groundwater remedy to be protective in the long-term, the HHRA and groundwater trigger levels need to be updated, potential ecological risk to aquatic receptors should be evaluated, the selected remedy needs to be modified to address VOC contamination, a point-of-compliance well and other characterization wells need to be installed at IR-07, and appropriate responses to incidences where trigger levels are exceeded must continue to be implemented.

Recommendations and Follow-up Actions for Groundwater. The five-year review identified the following actions related to the groundwater remedy. Each bullet also indicates how these items are addressed in the TMSRA.

- Refinement of Parcel B groundwater monitoring will be discussed with the regulatory agencies and detailed in the basewide monitoring plan, which encompasses groundwater monitoring for Parcels B, C, D, E, and E-2. The remediation alternatives in the TMSRA discuss groundwater monitoring options.

- Trigger levels should be reevaluated. Appendix I of the TMSRA contains recommendations for revised trigger levels.

- Ambient metals in groundwater may be reevaluated, if necessary, to ensure protectiveness of human health and the environment. Ambient levels of metals in groundwater are considered in the risk assessments in the TMSRA.

- Update the HHRA with new toxicological data and calculate cumulative risk as part of the ROD amendment process. The updated HHRA in the TMSRA incorporates new toxicological data and provides information about total risk.

- Potential ecological risk to aquatic receptors from Parcel B contaminants should be evaluated. The TMSRA contains an evaluation of potential risk to ecological receptors along the shoreline.

- Install a point-of-compliance well and characterization wells at IR-07. Point of compliance well IR07MWS-4 and post-remedial action wells IR07MW21A1, IR07MW24A, IR07MW25A, and IR07MW26A were reinstalled in March 2004 and the TMSRA uses data from these wells.

- Effectiveness of SVE and ZVI treatability studies should be evaluated and included in an amended ROD if either is selected as a remedy for VOC-contaminated groundwater. The TMSRA evaluates SVE and ZVI treatability studies and includes these technologies in remediation alternatives.

- Enforceable land-use restrictions need to be developed before the remedy is complete. The TMSRA contains more detailed information on potential institutional controls.

Radiological Issues and Recommendations. The five-year review indicated that the ROD amendment should memorialize the methods and cleanup goals for radiological contaminants being addressed by the basewide radiological removal action. Radiological issues are addressed in the radiological addendum to the TMSRA (Tetra Tech EC, Inc. 2007). This approach is consistent with the planned issuance of radiological addenda for feasibility studies at other parcels at HPS.

2.2 UPDATED CONCEPTUAL SITE MODEL

This section describes the changes in the physical characteristics of Parcel B since the ROD and changes to the site conceptual model for soil and groundwater based on information gained through investigations, removals, remedial actions, and treatability studies completed since the ROD. Refer to the FS report for discussions of physical characteristics that have not changed (for example, climate and topography) (PRC 1996).

2.2.1 Surface Features and Utilities

Some surface features and subsurface utilities have changed at Parcel B since the 1997 ROD. The Navy demolished Building 141 at IR-26 during 2000 as part of activities associated with Excavation EE-05. The Navy removed steam and fuel lines throughout Parcel B during remedial action excavations between 1998 and 2001. The Navy also removed an industrial drain line that serviced Building 123 during the 2000 to 2001 remedial action. As discussed in Section 2.1.3.2, the Navy studied the storm drain system throughout Parcel B to evaluate the potential for groundwater infiltration. The Navy plans to remove storm drains and sanitary sewers throughout HPS as part of ongoing survey and cleanup actions for the radiological program. Surveys and removal of storm drain and sanitary sewer system lines at Parcel B began in May 2006, and some of these removals will change the surface drainage at Parcel B.

2.2.2 Ecology

Most of Parcel B, approximately 75 percent, is covered by pavement and buildings. With little open space for flora and fauna, Parcel B is considered to have insignificant habitat value and poses an insignificant risk to terrestrial ecological receptors. Exposure pathways to terrestrial species are incomplete because of a lack of habitat and the predominance of paved areas in Parcel B (PRC 1996). However, potential ecological risk to receptors near the shoreline was not previously evaluated. The SLERA presented in Appendix B and further discussed in Section 3.2 evaluates ecological risks related to shoreline sediment as well as risks potentially posed by groundwater migration to the bay. Contaminants in shoreline sediment could result from overland transport of soil by runoff or by erosion of the shoreline and exposure of underlying soil.

The focus of the SLERA is the intertidal zone of the Parcel B shoreline, which incorporates portions of IR-07 and IR-26. The shoreline of IR-07 consists of about 1.5 acres that coincides with the southern portion of the India Basin. The IR-07 shoreline area includes approximately 1,300 square feet (ft^2) of tidal marsh wetlands. The shoreline of IR-26 consists of about 0.3 acre on the peninsula known as Point Avisadero (see Figures B-1 and B-2 in Appendix B). The shoreline of IR-26 is nearly completely covered by riprap for erosion control, with little or no interstitial soil between individual rocks. Field observations found that mainly invertebrates and birds use the shoreline habitat. Invertebrates included crabs and isopods that hide under rocks and feed on other small invertebrates. Mussels and barnacles are visible on the rocks at low tide.

Avian species reported or expected to forage along the shoreline or in adjacent offshore areas include the black-bellied plover, black turnstone, sanderling, long-billed curlew, dunlin, double-crested cormorant, surf scoter, American kestrel, red-tailed hawk, and peregrine falcon (Tetra Tech and Levine-Fricke-Recon, Inc. [LFR] 2000). In addition, the tidal wetlands may be used by shorebirds and wading birds, such as the willet, killdeer, and great blue heron.

Mammals observed along the Parcel B shoreline include the California ground squirrel, which uses the riprap areas for burrows. In addition, the house mouse is expected to use the shoreline.

The results of the SLERA in Appendix B indicate that potential risk to benthic invertebrates, birds, and mammals from several metals, pesticides, and polychlorinated biphenyls (PCB) in sediment along the Parcel B shoreline cannot be ruled out. Potential risk is also posed by concentrations of mercury in groundwater (see Appendix B). Section 3.2 contains a detailed discussion of the risk assessment completed for the SLERA.

2.2.3 Geology

The Navy's understanding of the geology of Parcel B presented in the 1997 ROD has been refined by advancing more than 100 soil borings and monitoring wells since 1997. The following paragraphs provide a brief review of the geology of Parcel B, including updated information, as applicable, based on the borings drilled at Parcel B since 1997.

The peninsula that forms HPS is within a northwest-trending belt of Franciscan Complex bedrock known as the Hunters Point Shear Zone. In some locations, the Marin Headlands Terrane underlies this shear zone. HPS is underlain by five geologic units: the youngest of Quaternary age; and the oldest, the Franciscan Complex bedrock, of Jurassic-Cretaceous age. In general, the stratigraphic sequence of these geologic units, from youngest (shallowest) to oldest (deepest), is as follows: Artificial Fill; Undifferentiated Upper Sand Deposits; Bay Mud Deposits; Undifferentiated Sedimentary Deposits; and Franciscan Complex Bedrock. Figure 2-4 presents three cross sections that illustrate the relationships between these units at Parcel B.

In the western portion of Parcel B (see cross section A-A'), Artificial Fill covers the entire surface, except for colluvium and alluvium on the hillside at the southern edge. The fill thickens from about 10 feet in the southwest to about 30 feet in the northeast near the bay. Undifferentiated Upper Sands, Bay Mud, and Undifferentiated Sedimentary Deposits also thicken from southwest to northeast, ranging from about 25 feet in the southwest to 30 feet in the northeast for all three units combined. The Bay Mud separates the Undifferentiated Upper Sands and Artificial Fill from the lower Undifferentiated Sedimentary Deposits over most of this area; however, the Bay Mud is absent in some areas and these two formations directly contact each other. For example, split-spoon samples collected during the installation of well IR18MW101B did not indicate Bay Mud was present at that location. The top of bedrock slopes gently downward from southwest to northeast and is about 55 feet bgs where the land surface meets the bay.

The central portion of Parcel B (see cross section B-B') is similar to the western portion, with colluvium and alluvium on the hillside and Artificial Fill covering the remainder of the surface. The fill in the central portion, however, is thicker, ranging from 15 feet in the southwest to 80 feet in the northeast, where the land surface meets the bay. The thicknesses and distribution of the Undifferentiated Upper Sands, Bay Mud, and Undifferentiated Sedimentary Deposits are more variable. Like the western area, the Bay Mud separates the Undifferentiated Upper Sands and Artificial Fill from the lower Undifferentiated Sedimentary Deposits over much of the central area; however, the Bay Mud is again absent in some areas and these two formations are adjacent. In the central area, split-spoon samples collected from boring IR10B003 did not indicate that the Bay Mud was present. The top of bedrock slopes more steeply toward the bay and reaches about 125 feet bgs at boring IR24B014, near the bay margin.

The eastern portion of Parcel B (see cross section C-C') that includes the peninsula called Point Avisadero is characterized by a thin layer of Artificial Fill over bedrock. The fill ranges in thickness from about 15 to 20 feet in the western and central parts of the peninsula to 5 feet or less along the eastern bay margin. Minor Undifferentiated Upper Sands are present, but Bay Mud and Undifferentiated Sedimentary Deposits are largely absent in this part of Parcel B.

The Franciscan Complex contains a variety of rock types including basalt, chert, sandstone, shale, and serpentinite. Some of these rock types contain wide-ranging concentrations of naturally occurring metals; serpentinite also contains naturally occurring asbestos minerals. Both metals and asbestos influence the remediation alternatives considered later in this TMSRA.

2.2.4 Hydrogeology

The Navy's understanding of the hydrogeology of Parcel B has changed since the 1997 ROD. Descriptions and interpretations presented in the "Distribution of the Bay Mud Aquitard and Characterization of the B-Aquifer Technical Memorandum" (Tetra Tech 2001b) encompass most of the updates to the hydrogeology at Parcel B. The following paragraphs provide a brief review of the hydrogeology of Parcel B, including updated information, as applicable, based on the more than 50 monitoring wells installed at Parcel B since 1997.

2.2.4.1 Hydrostratigraphic Units

The hydrostratigraphic units at HPS include (1) the A-aquifer, (2) the aquitard, (3) the B-aquifer, and (4) the deep bedrock water-bearing zone. The A-aquifer at Parcel B consists mainly of unconsolidated Artificial Fill that overlies the aquitard and bedrock and forms a continuous zone of unconfined groundwater across the parcel. Alluvium and colluvium, Undifferentiated Upper Sand Deposits, and shallow bedrock also are part of the A-aquifer at various locations across Parcel B. The A-aquifer generally thickens from about 15 feet in the southwest to as much as 80 feet in the northeast, but averages about 25 feet thick over most of Parcel B.

The B-aquifer consists mainly of Undifferentiated Sedimentary Deposits that overlie bedrock or are contained within the Bay Mud Deposits at a few locations near the bay margin. The B-aquifer is not continuous across Parcel B but exists primarily in two separate areas—along the western parcel boundary, and in a portion of the central area of the parcel. The B-aquifer ranges in thickness from about 5 to 15 feet where it is present and averages 10 feet thick.

Bay Mud Deposits act as an aquitard that separates the A- and B-aquifers over most of the parcel, except for part of the western portion at IR-18 and some of the central portion in IR-10, where the Bay Mud is absent and the A- and B-aquifers are adjacent. Hydraulic communication is restricted, although not prevented, in areas where Bay Mud Deposits are present, and the potential for communication between the A- and B-aquifers is greater where the Bay Mud Deposits are absent. However, previous investigations (Tetra Tech 2001b) concluded that, although lithologic data suggest the potential for communication, chemical results do not indicate communication exists. In addition, groundwater elevation data for the A- and B-aquifers in the western portion of IR-18 consistently indicate the vertical groundwater flow gradient is directed upward from the B- to the A-aquifer in this area. The Bay Mud Deposits generally thicken from where they pinch out against the historical shoreline in the southwest to 40 feet near the bay margin in the northeast. Dredging has removed the Bay Mud and B-aquifer at various locations across Parcel B. Greater detail on the distribution of the Bay Mud and the B-aquifer is presented in the "Distribution of the Bay Mud Aquitard and Characterization of the B-Aquifer Technical Memorandum" (Tetra Tech 2001b).

Nearly all the groundwater monitoring wells at Parcel B are screened in the A-aquifer. Only two wells are screened in the B-aquifer, and no wells at Parcel B are screened in the bedrock water-bearing zone.

2.2.4.2 Groundwater Flow Patterns

In general, groundwater in the A-aquifer flows from south to north, toward San Francisco Bay. Figure 2-5 presents groundwater elevations in the A-aquifer measured in November 2004 and shows general directions of groundwater flow across Parcel B. Based on tidal influence studies conducted during the RI (PRC and others 1996) and the FS (PRC 1996), the tidal influence zone extends inland up to about 300 feet from the shoreline. Tidal influence is the periodic fluctuation in the elevation of the groundwater table with time, caused by tidal fluctuations in the bay. Hydrographs from A-aquifer wells within the tidal influence zone show a direct correlation with bay elevations and, in general, show a change in groundwater elevation of more than 0.1 foot over a tidal cycle. Tidal influence may also mix groundwater with bay water, but mixing usually does not occur as far inland as do the fluctuations in groundwater elevation.

2.2.4.3 Beneficial Use of Groundwater

This section summarizes the beneficial use evaluation conducted for groundwater underlying Parcel B. Appendix E contains the complete beneficial use evaluation. The evaluation considers the current Water Quality Control Plan (Basin Plan) for the San Francisco Bay Basin (Water Board 2004), which identifies the following existing and potential beneficial uses for groundwater: municipal and domestic water supply, industrial water supply, industrial process water supply, and agricultural water supply.

A-Aquifer. The Water Board has already concluded that the A-aquifer at HPS is unsuitable as a potential source of drinking water (Water Board 2003c). The A-aquifer at Parcel B is also considered unsuitable by the Navy as a potential source of drinking water based on an evaluation of the site-specific factors identified in EPA's letter to the Navy (EPA 1999a). Appendix G contains the Water Board determination and EPA's 1999 letter.

B-Aquifer. Based on total dissolved solids data alone, the B-aquifer at Parcel B would be considered suitable as a potential source of drinking water. However, results of the evaluation of site-specific factors indicate that the B-aquifer has a low potential for use as a source of drinking water. These site-specific factors include (1) the City of San Francisco's prohibition on installing domestic wells and the proximity of sewer lines and storm drains, (2) the lack of current or historical use of the aquifer for water supply, (3) the limited size of this groundwater resource, and (4) the proximity of saltwater to the aquifer and the potential for saltwater intrusion if significant quantities of groundwater are withdrawn from the aquifer.

The evaluation of the B-aquifer suggests that it has a low potential as a source of drinking water. However, the groundwater ingestion pathway is included in the human health risk assessment for the B-aquifer groundwater because of agreements with the BCT on the methodology for the human health risk assessment (see Section 3.0 and Appendix A), and because the groundwater in the B-aquifer has not been exempted from the potential municipal and domestic beneficial uses specified in the Water Quality Control Plan for the San Francisco Bay Region. This assumption provides an additional measure of conservatism in protection of human health at HPS.

2.3 UPDATED CHARACTERIZATION OF SOIL AND GROUNDWATER

This section presents an overview of the updated extent of contamination present in Parcel B soil and groundwater to (1) support risk assessment and risk management, and (2) focus remedial action objectives on active remediation of selected soil areas and groundwater plumes. This section uses the results of the HHRA, summarized in Section 3.0 and fully detailed in Appendix A, to focus the presentation on the identified COCs that present potentially unacceptable risk. COCs are the analytes that pose an excess lifetime cancer risk greater than 1E-06 or yield a segregated hazard index greater than 1. The nature and extent of contaminants in soil and groundwater at Parcel B were presented in the previous RI and FS reports (PRC and others 1996; PRC 1996).

The nature of contaminants at Parcel B can mostly be attributed to industrial activities by the Navy or other tenants, except for several ubiquitous metals present throughout Parcel B. The position that discrete releases of chemicals (the "spill model") were the sources for contamination that was the basis for the ROD and remedial actions was not valid everywhere at Parcel B. Although the Navy successfully achieved the ROD remediation goals at the majority of excavations conducted during the remedial actions, the conceptual site model needs to be supplemented to account for the ubiquitous nature of metals contained in the fill used to construct many areas of Parcel B and to address the use of debris as fill at IR-07/18. The spill model for chemical releases does not apply to the debris fill at IR-07/18 or for other areas where quarried native rock was used as fill. The remedial alternatives proposed in the TMSRA address these changes to the conceptual site model.

In the TMSRA, the term "ubiquitous" refers to metals that are naturally occurring or are in the same concentration ranges as naturally occurring metals in the source material (including material from the same geologic formations in the San Francisco area) used for filling operations at HPS. The Navy acknowledges that industrial sources of metals exist at HPS and there is a potential that some concentrations of metals could have sources other than naturally occurring materials. The Navy has worked to remove these sources during the response actions taken to date. The Navy acknowledges that the regulatory agencies do not agree with the Navy's position that ubiquitous metals are naturally occurring. Remedial alternatives developed in this TMSRA address these concentrations of metals, regardless of their source.

The Navy maintains a comprehensive database of analytical results reported at HPS for both soil and groundwater. This section is intended to provide an overview of the extent of chemicals that pose the greatest risk at Parcel B. Consequently, sample-specific data are not presented in the figures and tables of this section. Appendix F (provided on compact disk only) contains a searchable database of all chemical analytical data for soil and groundwater at Parcel B used in this TMSRA, including pre-established queries for printing data reports.

2.3.1 Overview of Soil

The COCs in soil at Parcel B after the remedial and removal actions of 1998 through 2005 have not changed substantially compared with those identified in the 1997 ROD and the subsequent RD. Table 2-4 lists the broad categories of COCs in soil at Parcel B as well as potential sources for these chemicals. Although the list of COCs has not changed significantly, the volume of soil contaminated by these COCs, especially organic compounds, is much smaller now than in 1997. In addition, the Navy's knowledge of the distribution of inorganic chemicals in native soil and artificial fill has increased greatly as a result of the extensive excavations and sampling at Parcel B since 1998. In particular, the ubiquitous nature of metals in fill is much clearer now than during the initial design of the remedial action and is a large part of the reason for the reevaluation presented in this TMSRA.

The distribution of arsenic in soil is used to illustrate the widespread occurrence of naturally occurring metals in the fill used to create Parcel B. Figure 2-6 illustrates the distribution of arsenic in post-excavation soil samples collected between 0 and 10 feet bgs. The data ranges on Figure 2-6 were selected to illustrate concentrations above and below the HPAL (11.1 mg/kg) for arsenic. Although apparent clusters of higher arsenic concentrations appear in two locations, most arsenic concentrations are distributed across Parcel B with no apparent pattern to indicate their presence due to a release. Both locations on Figure 2-6 that indicate high concentrations of arsenic (red symbols) represent bottom composite samples collected after excavations were completed. This distribution of arsenic remains intact even though the Navy has removed more than 100,000 cubic yards of soil from Parcel B. The Navy believes that arsenic is naturally occurring in the local bedrock that was used for fill and this is the source of the arsenic present throughout Parcel B. This same condition is true for a group of commonly detected metals at Parcel B, including aluminum, antimony, cadmium, chromium, copper, iron, magnesium, manganese, nickel, vanadium, and zinc and also for less commonly observed metals such as barium, beryllium, molybdenum, selenium, silver, and thallium. The Navy acknowledges that industrial sources for metals exist and that there is a potential that some concentrations of metals could have sources other than naturally occurring rock. The Navy has worked to remove these sources during the response actions taken to date. However, the widespread distribution of metals remaining in soil is consistent with the concentrations present in native rock. Remedial alternatives in this TMSRA will be designed to be protective of risks from these metals concentrations, regardless of source. Section 3.0 and Appendix A present the risk associated with all these metals based on the samples that remain in place.

The Navy's knowledge of the distribution of chemicals in shoreline sediment has also increased greatly since 1997. Further characterization of the shoreline was completed in 2003 including collection of sediment samples along the shoreline at IR-07 and IR-26. The sample data are presented in the shoreline characterization technical memorandum (Tetra Tech and ITSI 2004b). Samples collected during the Parcel B shoreline characterization form the basis for the SLERA (see Appendix B). Sample locations and analysis of the sediment data are included in Appendix B.

2.3.2 Overview of Groundwater

The characterization of COCs in groundwater at Parcel B has increased greatly since the 1997 ROD. The implementation of the RAMP in 1999 and the subsequent, continuous quarterly monitoring have increased the knowledge of the distribution of chemicals in groundwater. The RAMP began with 24 wells and expanded to include new wells as monitoring results indicated the need for additional data. The Navy currently collects samples from 39 wells under the RAMP (also refer to Section 2.1.3.2). The groundwater data used in this TMSRA include samples collected through November 2004. Narrative descriptions of groundwater data in the text of the TMSRA have been updated to account for samples collected through March 2007. However, data sets (for example, those used for the HHRA and SLERA) have not been updated. The Navy has reviewed the results of samples collected after November 2004 and has found no reason to expect the new data to change the groundwater characterization.

COCs in groundwater in the A-aquifer based on the HHRA and SLERA include (1) VOCs, especially trichloroethene and its breakdown products, (2) chromium VI, and (3) mercury. An additional screening evaluation of surface water quality to evaluate potential ecological risks from exposure to groundwater as it interacts with surface water indicates that potential risk may be posed by chromium VI, copper, lead, and mercury. (See Appendix I for this surface water quality evaluation.) Some of these COCs are found in samples from multiple wells and represent plumes in groundwater. Other COCs are found in only individual wells and are not referred to as plumes. One plume of VOCs is found in a group of wells located at IR-10 and is termed the IR-10A risk plume in the HHRA (please refer to Appendix A, Attachment A4 for the definitions and methodology behind selection of risk plumes). This plume was the target of a ZVI injection treatability study and has been monitored for many years under the RAMP. Chromium VI has been detected consistently in samples from well IR10MW12A and has historically been termed a "plume" even though detections have been limited to a single well. The HHRA and the TMSRA maintain that convention and refer to the chromium VI concentrations at well IR10MW12A as the IR-10B plume. Figure 2-7 shows the locations of VOCs and chromium VI at IR-10. Mercury has been detected consistently in samples from wells IR26MW47A and IR26MW49A, and the TMSRA includes a plume that encompasses these two wells. The locations of wells IR26MW47A and IR26MW49A are shown on Figure 2-3 near the eastern edge of Parcel B. Copper and lead were detected infrequently at individual wells (copper at IR07MW20A and lead at IR07MWS-2 and IR26MW48A) with no defined groundwater plumes. The remainder of this section discusses these COCs in greater detail in preparation for the HHRA discussion to follow in Section 3.0.

The areal extent of the IR-10A plume near Building 123 is stable, and concentrations within the plume are decreasing as the result of ZVI injection during treatability study testing. Maximum concentrations of VOCs measured in samples collected during November 2004 include 340 micrograms per liter (μg/L) of trichloroethene, 200 μg/L of cis-1,2-dichloroethene, and 170 μg/L of vinyl chloride. Figures 2-8, 2-9, and 2-10 illustrate the distributions of these three VOCs in groundwater near Building 123 based on the November 2004 samples (Kleinfelder 2005). Samples collected in March 2007 indicated maximum concentrations of 120 μg/L trichloroethene, 140 μg/L cis-1,2-dichloroethene, and 28 μg/L vinyl chloride (CE2-Kleinfelder 2007e).

The plume of chromium VI (IR-10B) near Building 123 was found to be confined to a single well (IR10MW12A) during the delineation investigation in 2002. Building 123 was used as a plating shop. The lithologic logs for borings in the area show that soil surrounding monitoring well IR10MW12A is made up of Artificial Fill, with clay derived from both Bay Mud and bedrock. Chromium VI may have been spilled from the wooden loading dock and ramp outside of Building 123 and settled into gravel that had been placed in the area for building construction. Other potential chromium VI sources include storm drain and sanitary sewer lines, an acid drain line and associated tank, a concrete vault, and a brick unit all of which were inside Building 123 adjacent to well IR10MW12A (refer to Appendix H for more details). Low-conductivity clay in the Artificial Fill may act as a physical and chemical barrier to migration of chromium VI from the gravel repository and may be the reason chromium VI is rarely detected at any well other than IR10MW12A. The concentration of chromium VI was 260 μg/L in the sample from well IR10MW12A collected in November 2004. The maximum concentration of chromium VI detected at well IR10MW12A was 680 μg/L (collected in December 2005). The maximum concentration of chromium VI in the HHRA data set was 550 μg/L (collected in March 2004). Well IR10MW12A was decommissioned in July 2006 and replaced by well IR10MW82A, located about 13 feet northeast of former well IR10MW12A. The concentration of chromium VI was 0.86 μg/L in the sample from well IR10MW82A collected in May 2007. Figure 2-11 illustrates the distribution of chromium VI in groundwater near Building 123.

Two other plumes of VOCs are present in groundwater in the A-aquifer adjacent to Parcel B at RU-C5 in Parcel C. These plumes include trichloroethene and its breakdown products and are related to activities at IR-06 (a former fuel tank farm) and IR-25 (the sump and dip tank within Building 134). VOCs are present in groundwater at RU-C5 as dense nonaqueous-phase liquids. The extent of plumes at RU-C5, including whether the plumes extend into Parcel B, was investigated between August 2005 and March 2006. The investigation found that, although dissolved phase VOCs have migrated into Parcel B, concentrations of VOCs in this area were below MCLs. Although the current data for VOCs in groundwater at RU-C5 do not indicate that the plumes extend into Parcel B, the HHRA (see Section 3.0 and Appendix A) uses a risk plume approach that includes data from the most recent 12 rounds of groundwater monitoring from each well. As a result, a VOC risk plume has been identified in the HHRA for the areas of Parcel B near the current RU-C5 plumes. The risk plume near at RU-C5 is termed the IR-25 plume in the HHRA.

Groundwater samples from well IR26MW47A have indicated consistent detections of mercury from March 2002 when the well was installed through March 2007. Mercury concentrations ranged up to 2.8 μg/L (November 2004) during this time period. However, mercury was not detected in samples from nearby wells IR26MW46A and IR26MW48A during the same period. Mercury was also detected in groundwater samples collected at new well IR26MW49A that was installed in July 2006 downgradient from well IR26MW47A. Concentrations of mercury in samples collected from well IR26MW49A ranged from 0.88 μg/L in November 2006 to 0.96 μg/L in March 2007. Mercury detections in samples from wells IR26MW47A and IR26MW49A may be related to mercury observed in soil samples at nearby Excavation EE-05. The Navy removed more than 5,500 cubic yards of soil from Excavation EE-05, most during 2000 and 2001, and collected 326 confirmation soil samples from the excavation bottom and sidewalls. Mercury concentrations as high as 482 mg/kg were removed. Excavation EE-05 was completed to a depth of 10 feet bgs and mercury concentrations in all sidewall samples from the completed excavation were less than 2.3 mg/kg (the cleanup goal for mercury during the action). Mercury was detected in bottom composite samples at concentrations ranging from 0.2 to 90 mg/kg. Figure 2-12 shows the location of Excavation EE-05 and the surrounding monitoring wells. Figure 2-7 shows the approximate location of the mercury plume in groundwater.

The surface water quality evaluation indicated that copper and lead were COCs (copper at well IR07MW20A and lead at wells IR07MWS-2 and IR26MW48A). Detections of copper and lead in groundwater samples collected from these wells were infrequent and sporadic; however, copper and lead were conservatively included as COCs.

FIGURES

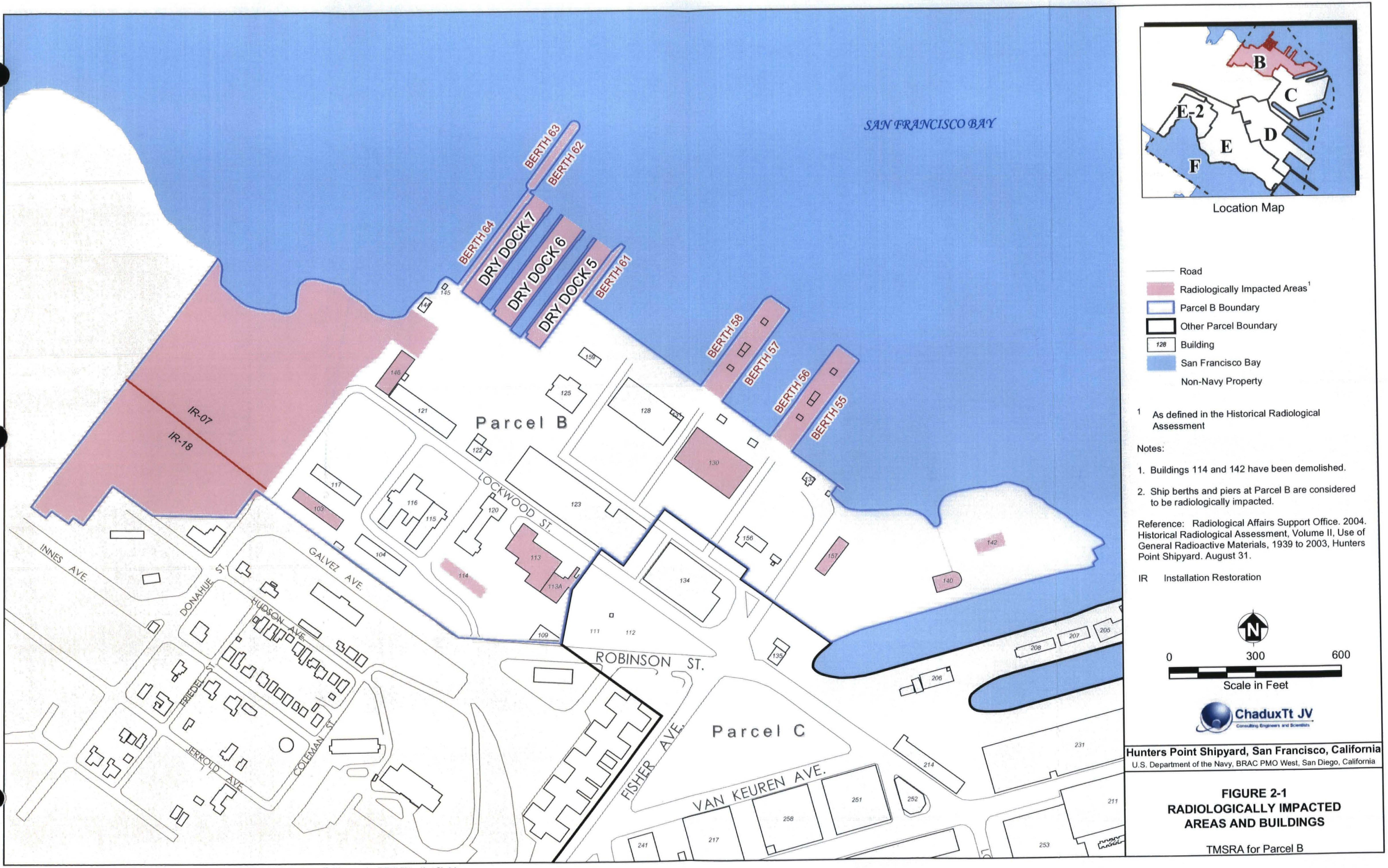

FIGURE 2-1
RADIOLOGICALLY IMPACTED AREAS AND BUILDINGS

TMSRA for Parcel B

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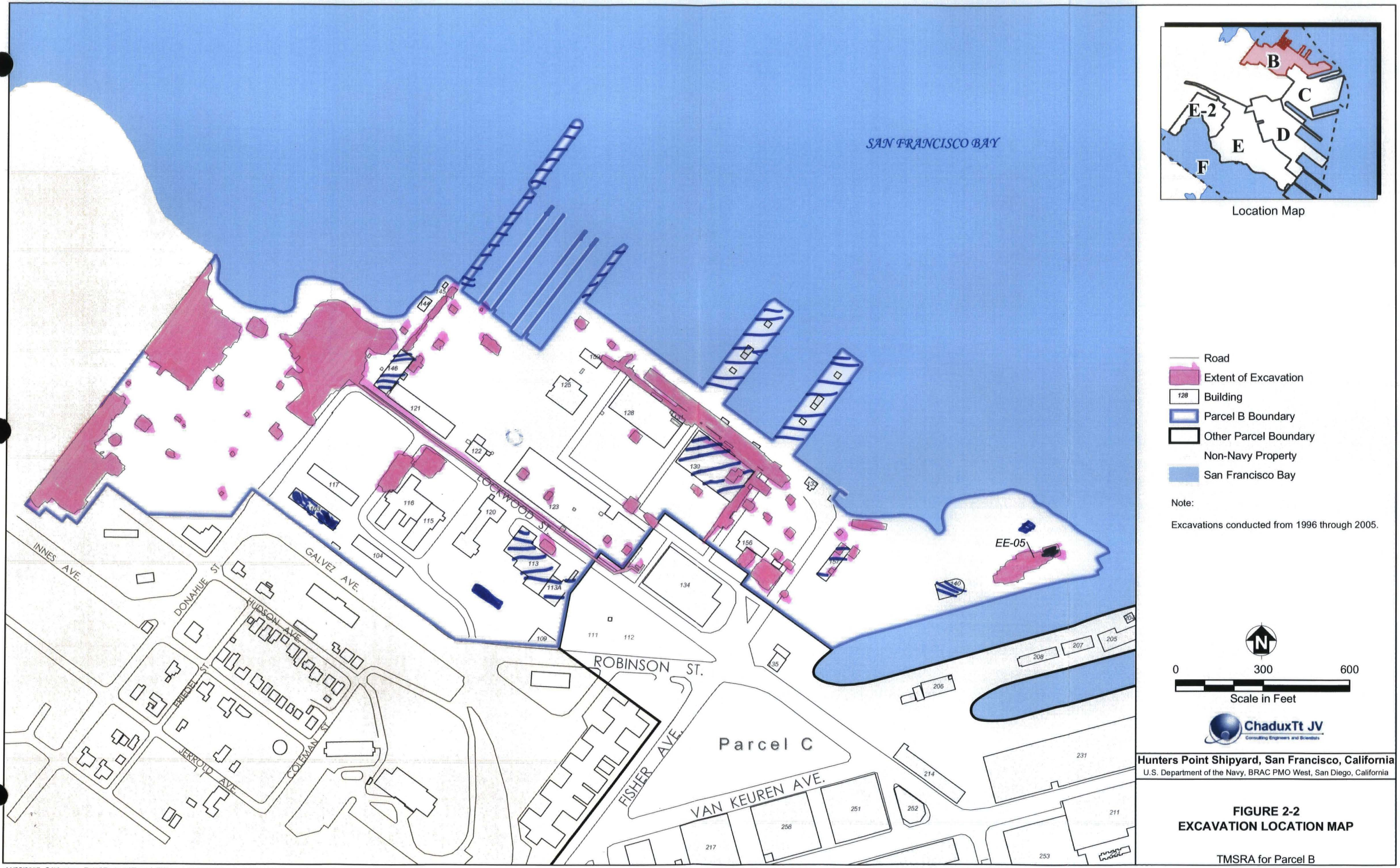

Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-2
EXCAVATION LOCATION MAP

TMSRA for Parcel B

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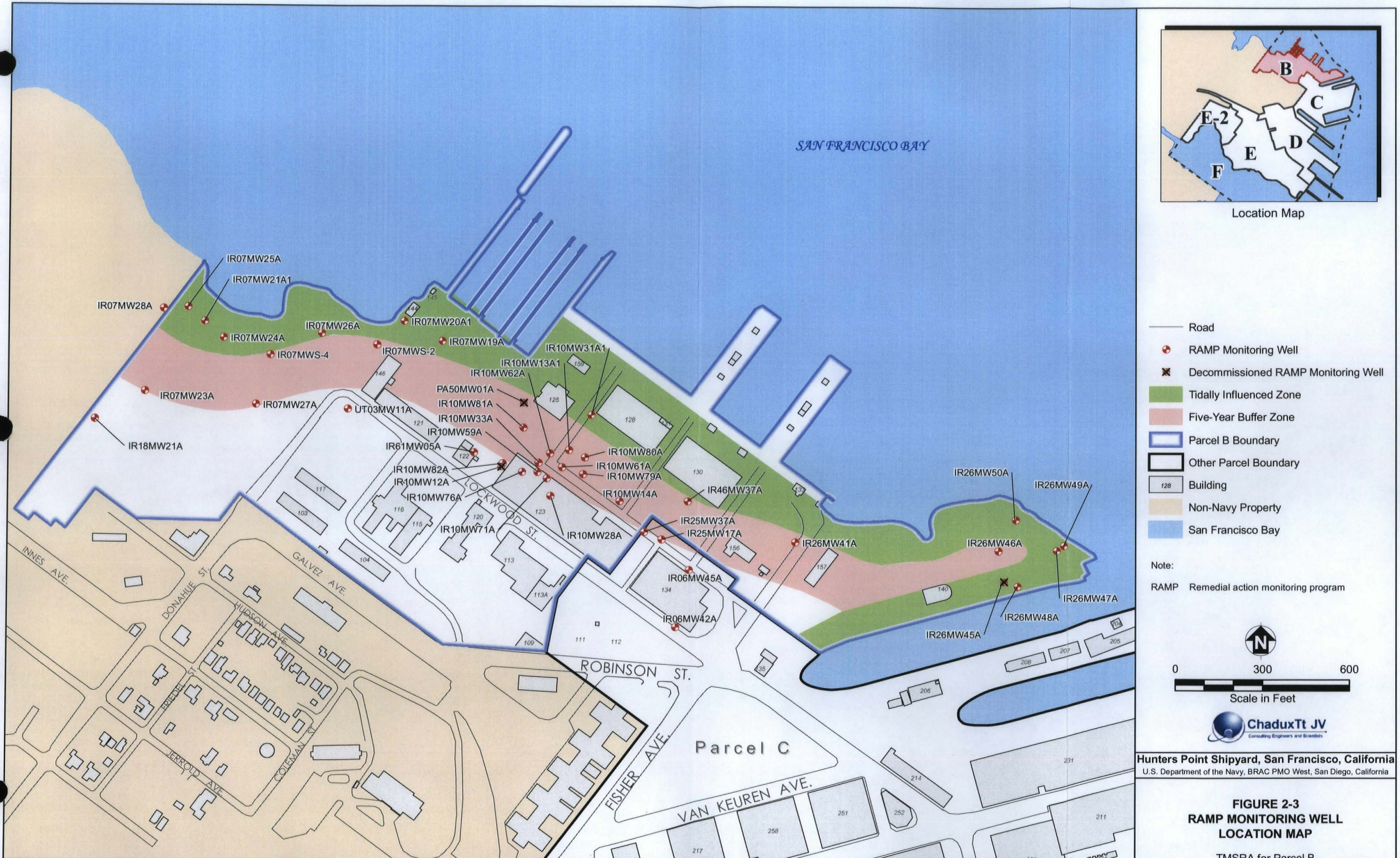

FIGURE 2-3
RAMP MONITORING WELL LOCATION MAP

TMSRA for Parcel B

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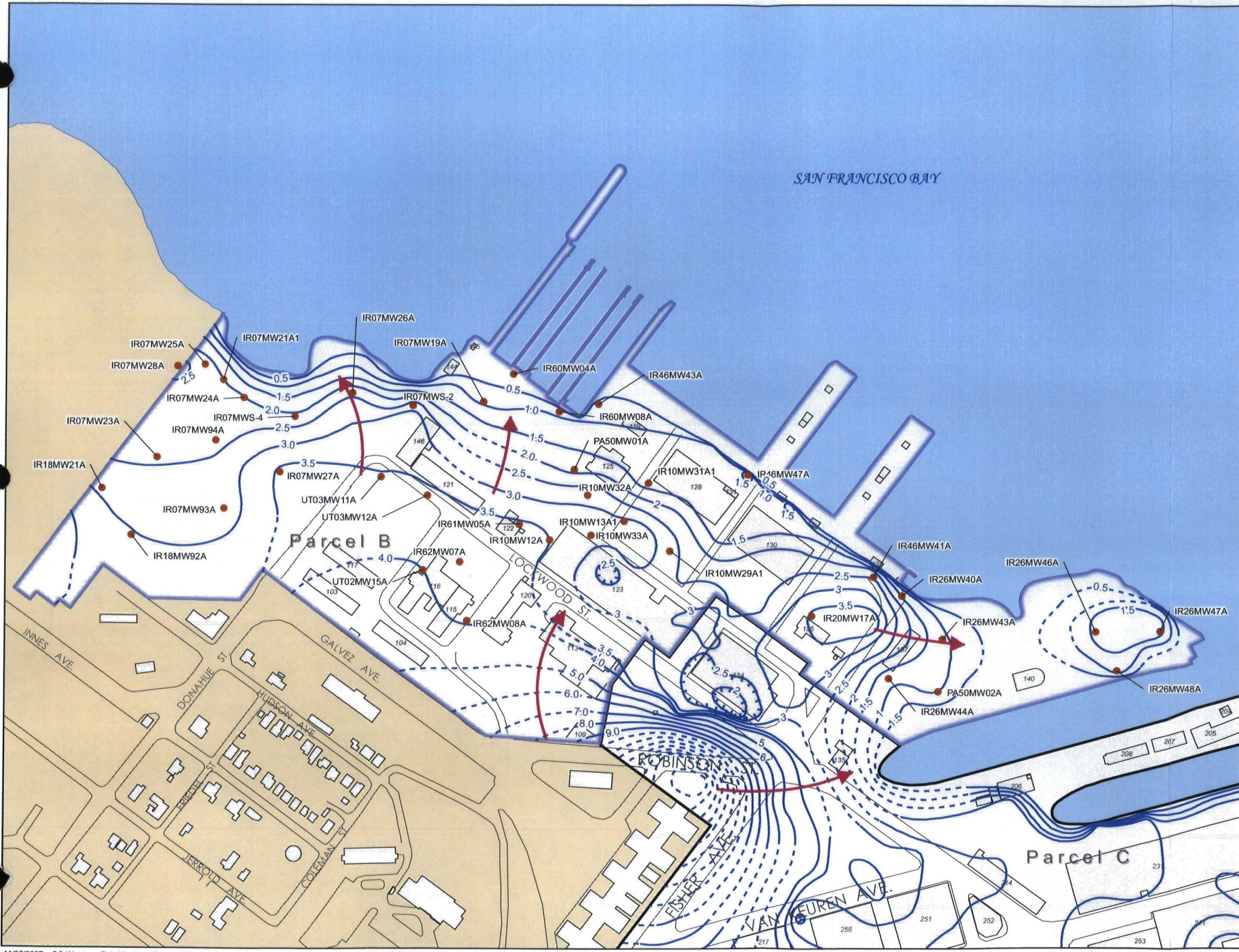
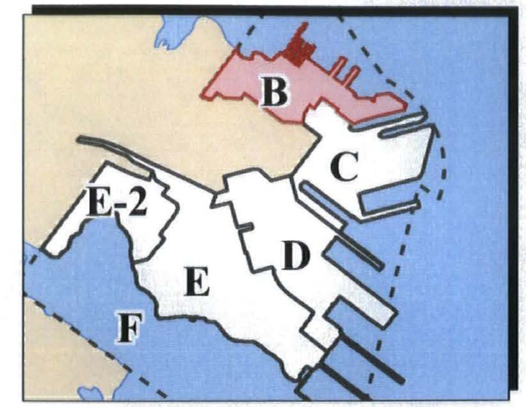
PARTIALLY SCANNED
OVERSIZE ITEM(S)

See document # 2259642
for partially scanned image(s).
FIGURE 2-4
(2 OF 5)

For complete hardcopy version of the oversize document
contact the Region IX Superfund Records Center





Location Map

- Monitoring Well
- A-Aquifer Groundwater Elevation Contour Line, (dashed where inferred)
- A-Aquifer Groundwater Elevation Depression Contour Line, (dashed where inferred)
- A-Aquifer Groundwater Flow Direction
- Road
- Parcel B Boundary
- Other Parcel Boundary
- 128 Building
- San Francisco Bay
- Non-Navy Property

Note:

Groundwater elevations derived from "Draft October to December 2004 Twentieth Quarterly/Fifth Annual Groundwater Sampling Report, Parcel B, Hunters Point Shipyard, San Francisco, California." Prepared by Kleinfelder, December 2, 2005.

0 300 600

Scale in Feet

ChaduxTt JV

Hunters Point Shipyard, San Francisco, California

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FIGURE 2-5
GROUNDWATER ELEVATION
A-AQUIFER
NOVEMBER 2004

TMSRA for Parcel B

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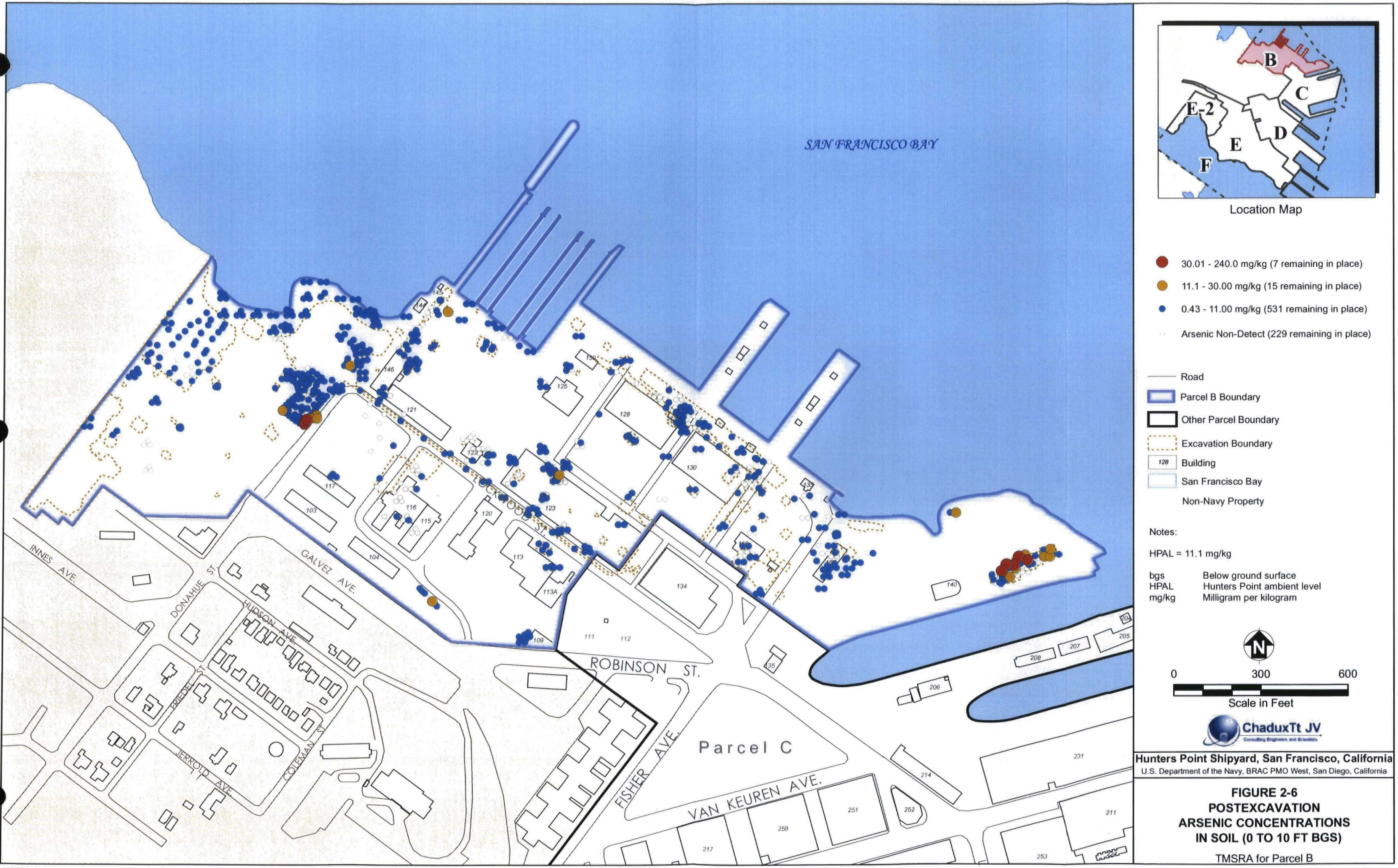

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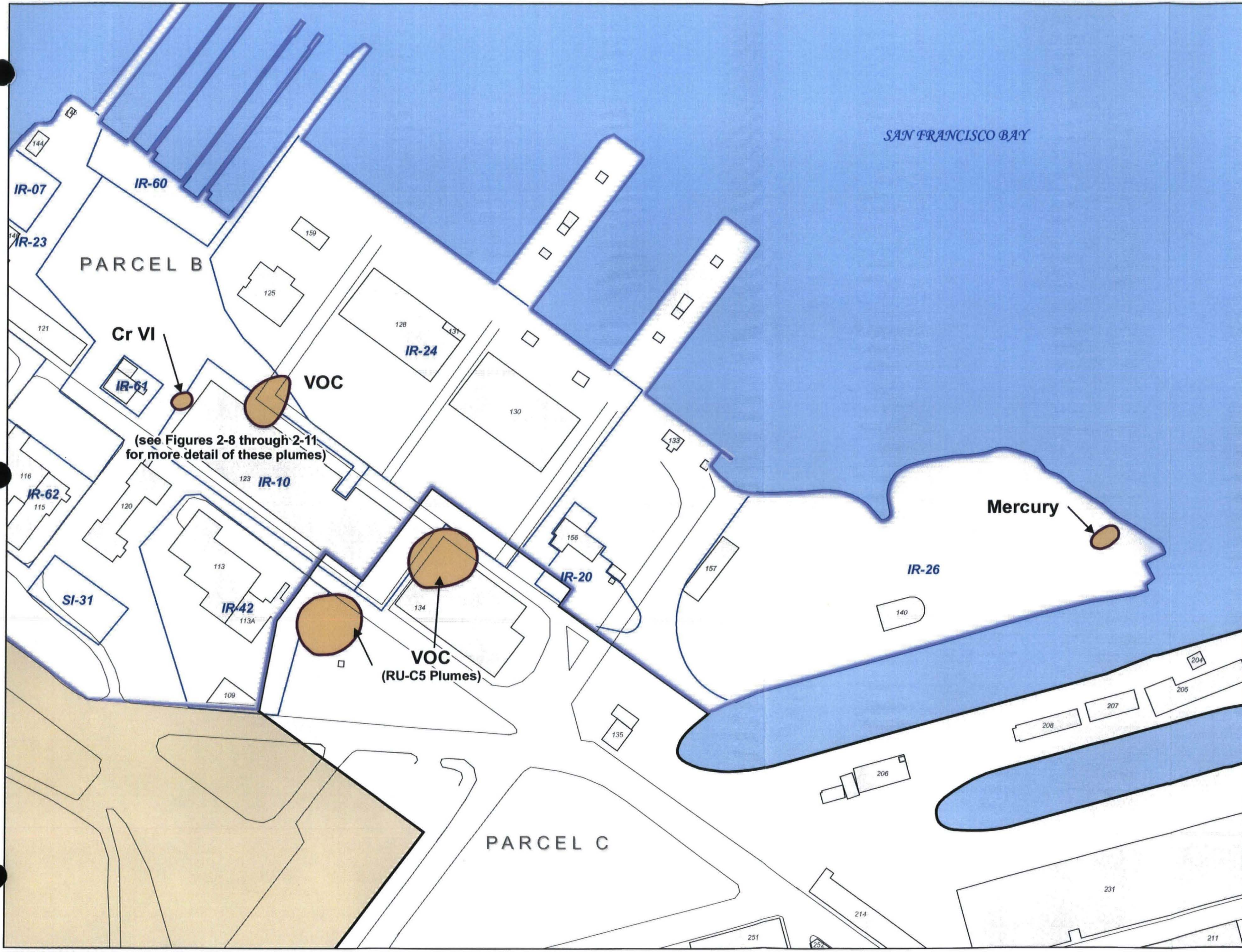
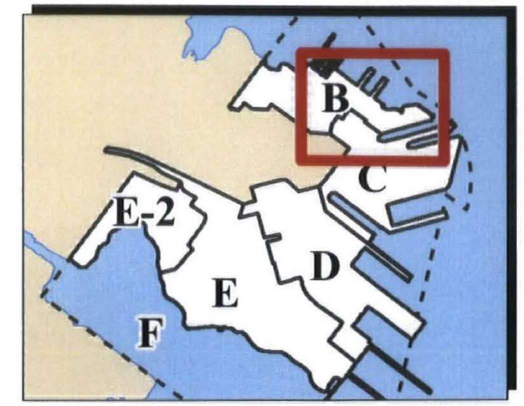
FIGURE 2-6
POSTEXCAVATION ARSENIC CONCENTRATIONS IN SOIL (0 TO 10 FT BGS)

TMSRA for Parcel B

11/05/2007 O:\Hunters_Point\Projects\Parcel_B\Parcel_B_TMSRA\projects\Fig2-06_Arsenic_Conc.mxd TtEMI-DN Kurt.Cholak





Location Map

	IR or SI Site
	Approximate Extent of Current Groundwater Plume
	Parcel B Boundary
	Other Parcel Boundary
	Non-Navy Property
128	Building
	San Francisco Bay

Notes:

Cr VI	Chromium VI
IR	Installation Restoration
RU	Remedial unit
SI	Site Inspection
VOC	Volatile organic compound

Plume locations based on samples collected in March 2007.

0 200 400
Scale in Feet

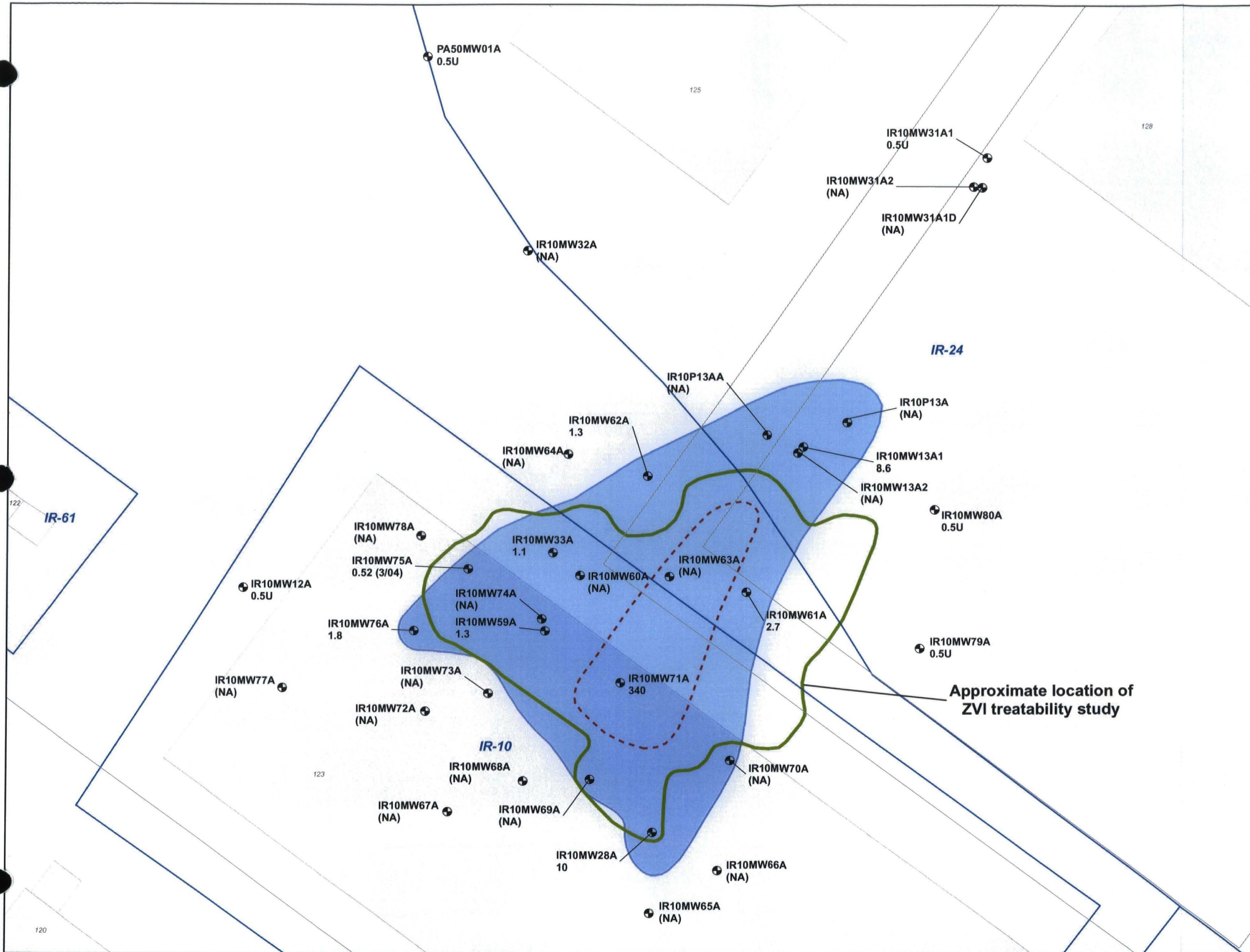
ChaduxTt JV

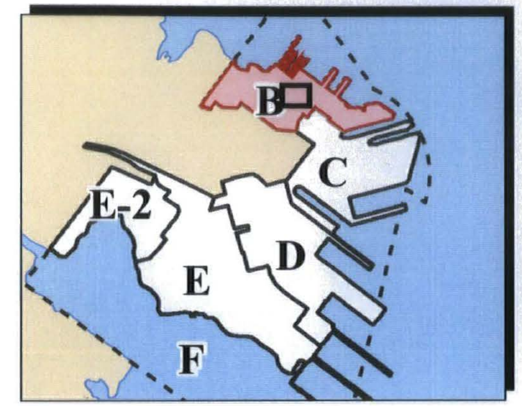
Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-7
LOCATION OF CURRENT GROUNDWATER PLUMES

TMSRA for Parcel B

11/30/2007 O:\Hunters_Point\Projects\Parcel_B\Parcel_B_TMSRA\projects\Fig2-07_Current_GW_PlumesSizeB.mxd TtEMI-DN Kurt.Cholak





Location Map

Monitoring well with TCE concentration measured November 2004 in µg/L (other sample dates in parentheses)

Road

Approximate Area of Highest TCE Concentrations, November 2004

Approximate Location of the ZVI Treatability Study Area

Approximate Extent of TCE Plume, November 2004

IR or SI Site

123 Building

Notes:

1. ZVI treatability study area based on Figure 3 of "Final Cost and Performance Report, Zero-Valent Iron Injection Treatability Study, Building 123, Parcel B, Hunters Point Shipyard, San Francisco, California." Prepared by ERRG and URS, June 2004.

NA	Not analyzed
U	Not detected
µg/L	Microgram per liter
TCE	Trichloroethene
ZVI	Zero-Valent Iron

N

0 40 80

Scale in Feet

ChaduxTt JV

Consulting Engineers and Scientists

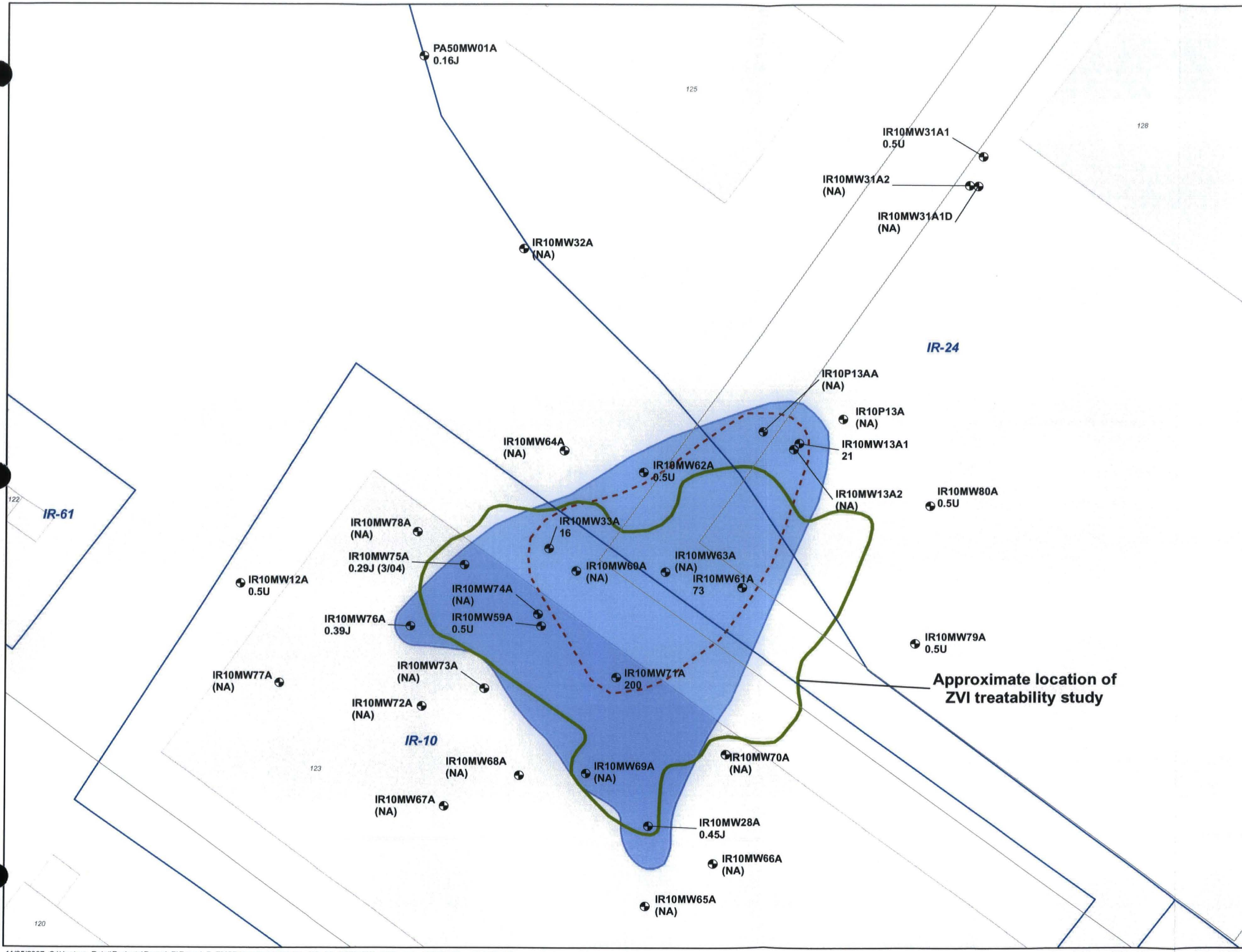
Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

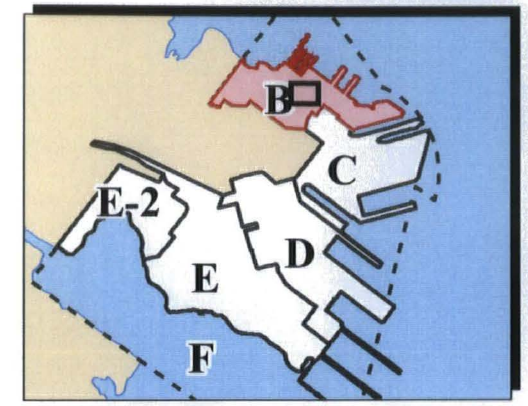
FIGURE 2-8
TCE IN GROUNDWATER
NOVEMBER 2004

TMSRA for Parcel B

11/05/2007 O:\Hunters_Point\Projects\Parcel_B\Parcel_B_TMSRA\projects\Fig2-08_TCEinGW_1104.mxd TtEMI-DN Kurt.Cholak



11/05/2007 O:\Hunters_Point\Projects\Parcel_B\Parcel_B_TMSRA\projects\Fig2-09_CIS_12_DCEinGW_1104.mxd TtEMI-DN Kurt.Cholak



Location Map

Monitoring well with cis-1,2-DCE concentration measured November 2004 in µg/L (other sample dates in parentheses)

Road

Approximate Area of Highest cis-1,2-DCE Concentrations, November 2004

Approximate Location of the ZVI Treatability Study Area

Approximate Extent of cis-1,2-DCE Plume, November 2004

IR or SI Site

123 Building

Notes:

1. ZVI treatability study area based on Figure 3 of "Final Cost and Performance Report, Zero-Valent Iron Injection Treatability Study, Building 123, Parcel B, Hunters Point Shipyard, San Francisco, California." Prepared by ERRG and URS, June 2004.

DCE	Dichloroethene
J	Estimated value
NA	Not analyzed
U	Not detected
µg/L	Microgram per liter
ZVI	Zero-Valent Iron

N

0 40 80

Scale in Feet

ChaduxTt JV

Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-9
CIS-1,2-DCE IN GROUNDWATER
NOVEMBER 2004

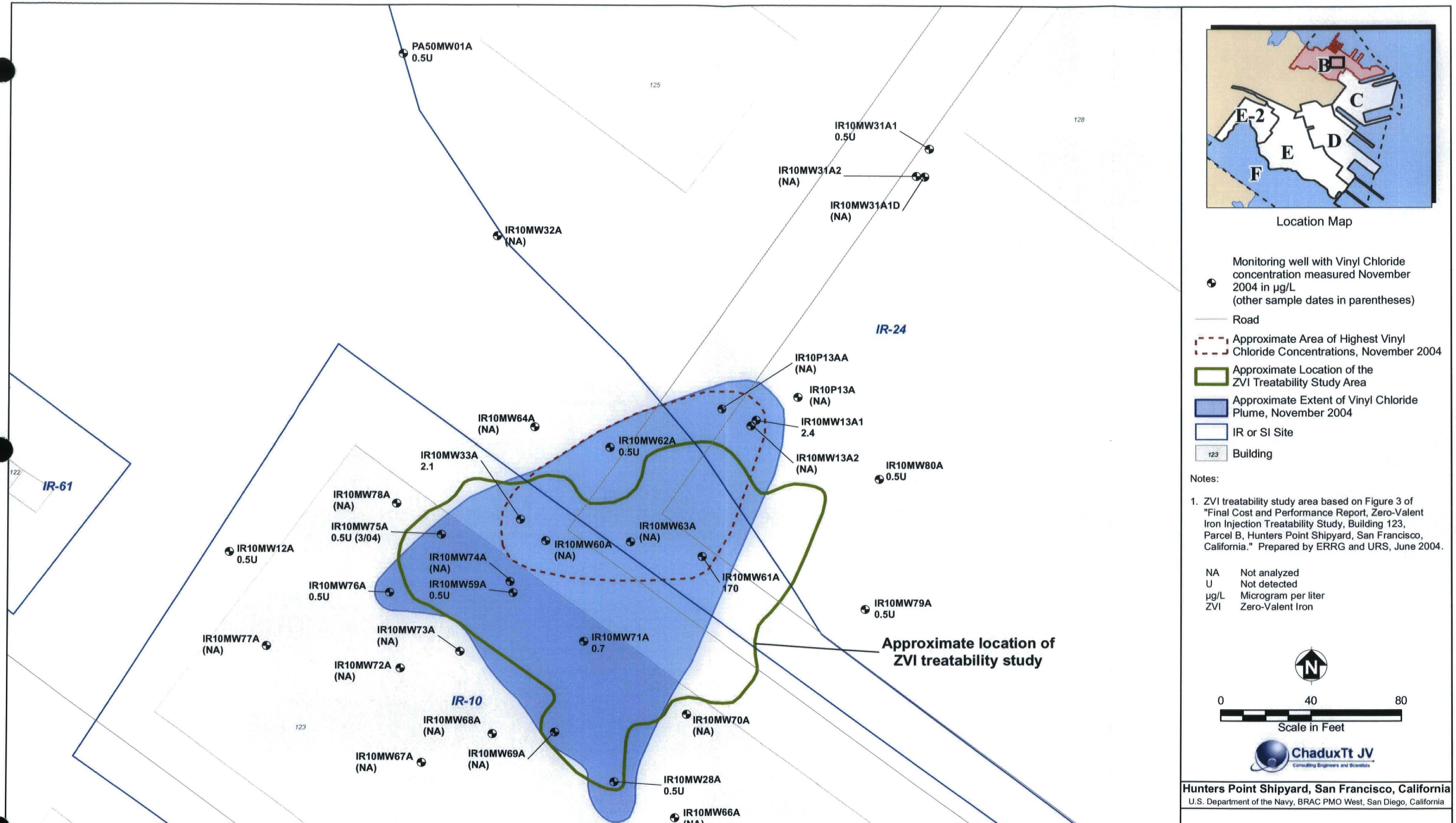
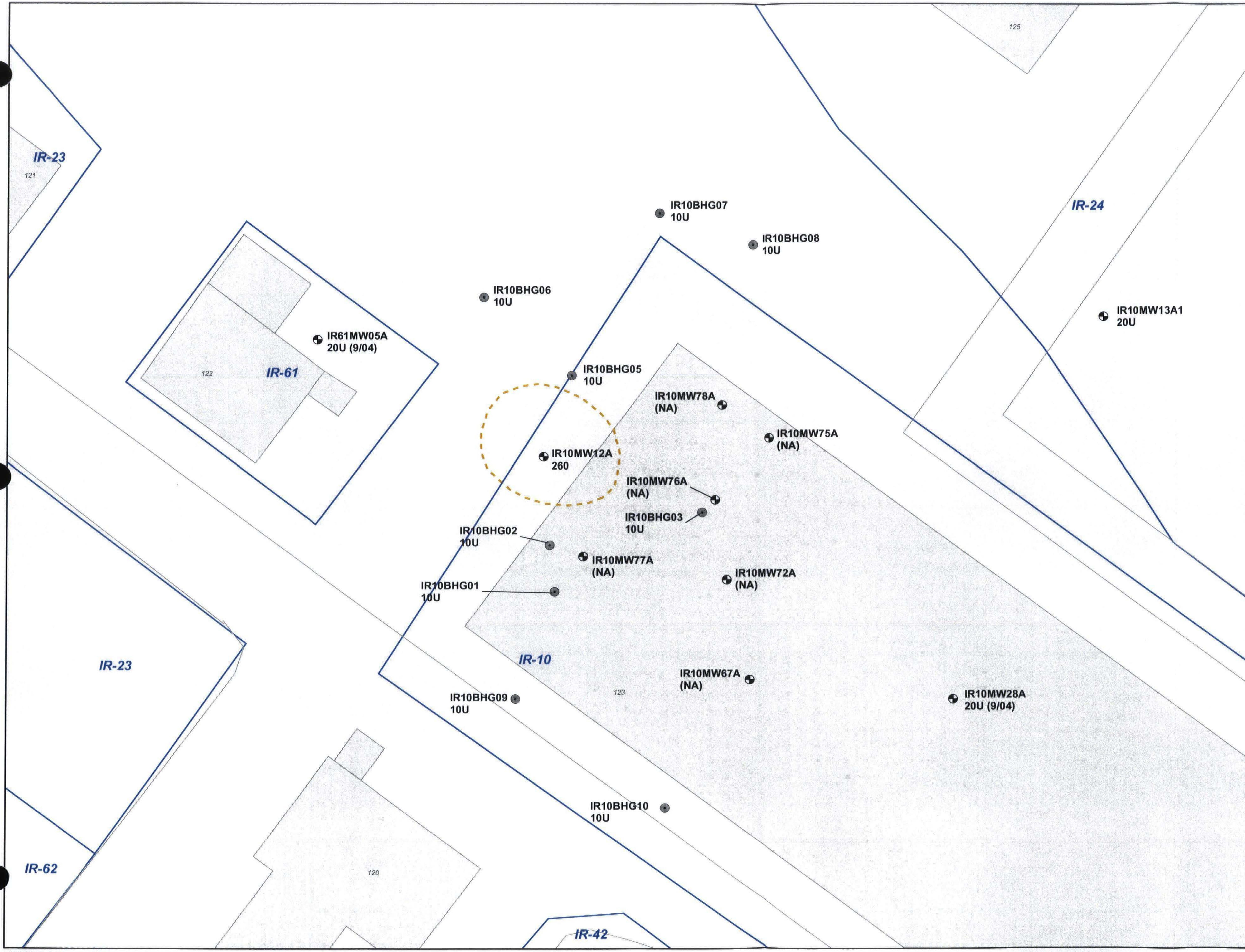
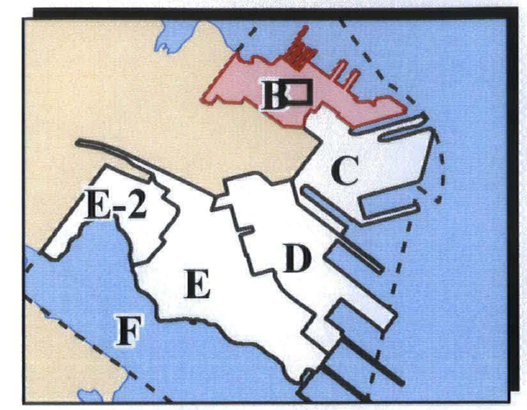


FIGURE 2-10
VINYL CHLORIDE IN GROUNDWATER
NOVEMBER 2004

TMSRA for Parcel B





Location Map

Monitoring well with chromium VI concentration measured November 2004 in µg/L (other sample dates in parentheses)

Temporary piezometer with chromium VI concentration measured September 2002 in µg/L

Road

Approximate Area of Highest Chromium VI Concentrations, November 2004

IR or SI Site

Building

Notes:

J Estimated value
NA Not analyzed
U Not detected
µg/L Microgram per liter

N

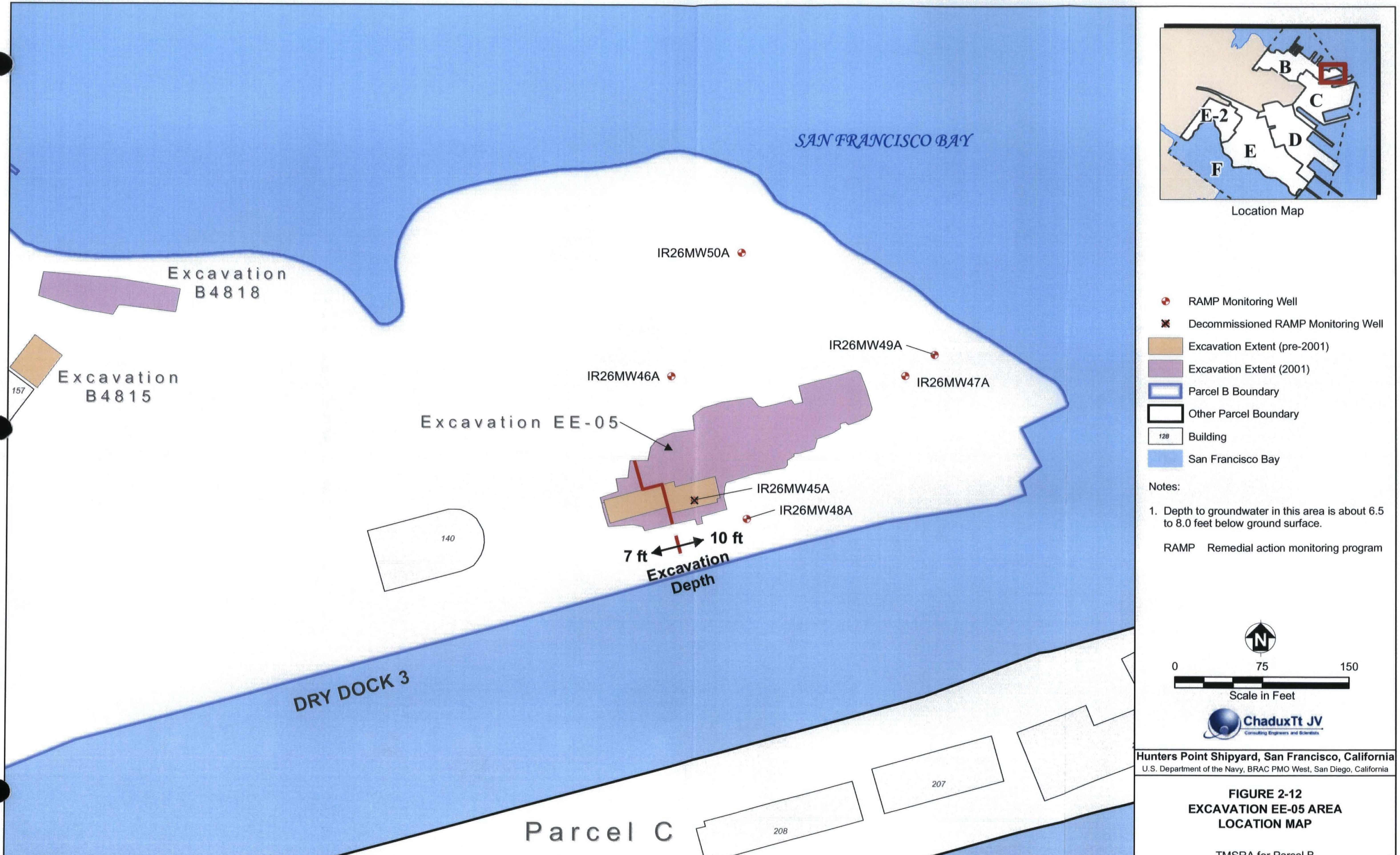
0 40 80
Scale in Feet

ChaduxTt JV
Consulting Engineers and Scientists

Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-11
CHROMIUM VI IN
GROUNDWATER NOVEMBER 2004

TMSRA for Parcel B



Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 2-12
EXCAVATION EE-05 AREA
LOCATION MAP

TMSRA for Parcel B

11/30/2007 O:\Hunters_Point\Projects\Parcel_B\Parcel_B_TMSRA\projects\Fig2-12_ExcavationEE-05.mxd TtEMI-DN Kurt.Cholak

TABLES

TABLE 2-1: HISTORY OF INVESTIGATIONS SINCE ROD

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Report Date	Title	Author	Activity Description
Soil Remedy-Related Documents			
8/4/99	Nickel Screening and Implementation Plan	Tetra Tech	Evaluation of ambient concentrations of nickel in soil across HPS
8/19/99	Remedial Design Documents	Tetra Tech and MK	Guided first phase of soil excavations from July 1998 to September 1999
8/00	Historical Radiological Assessment, Volume I, Naval Propulsion Program, 1966 to 1995	RASO	Evaluation of potential radiological contamination from maintenance of nuclear-powered ships
2/20/01	Remedial Design Documents Amendment	Tetra Tech	Guided second phase of soil excavations from July 2000 to December 2001
2/28/01	Calculation and Implementation of Supplemental Manganese Ambient Levels	Tetra Tech	Evaluation of ambient concentrations of manganese in soil across HPS
9/11/01	Final Manganese Site Proposal	Tetra Tech	Evaluation and proposal for action related to manganese concentrations in soil at Parcel B
11/18/02	Construction Summary Report (draft)	Tetra Tech	Summary of 78 soil excavations conducted during phases I and II of remedial action, mostly outside of IR-07 and IR-18
12/21/01	Final Evaluation of Ambient Manganese Conditions	Tetra Tech	Evaluation of ambient concentrations of manganese in soil across HPS
3/28/03	Interpretation of Fill Conditions at IR-07 and IR-18	Tetra Tech	Characterization of subsurface conditions using soil borings, geophysics, and historical aerial photographs
3/23/04	Shoreline Characterization Technical Memorandum	Tetra Tech	Characterization of shoreline sediments at IR-07 and IR-26
8/31/04	Historical Radiological Assessment, Volume II, Use of General Radioactive Materials, 1939 to 2003	RASO	Evaluation of potential radiological contamination from use of general radioactive materials across HPS
9/8/04	Construction Summary Report Addendum (draft)	SulTech	Summary of remaining 28 excavations conducted during phases I and II of remedial action
6/05	Draft Final Site Closeout Report, Total Petroleum Hydrocarbon Program Corrective Action Implementation Soil Removal for Parcels B, C, D, and E	TPA-CKY Joint Venture	Summary of excavations to remove petroleum-contaminated soil across HPS, including two excavations at Parcel B
9/23/05	Soil Gas Survey Technical Memorandum	SES-TECH	Soil gas survey for evaluation of methane and total volatile organic compounds to assess nature and extent of concentrations in soil gas

TABLE 2-1: HISTORY OF INVESTIGATIONS SINCE ROD (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Report Date	Title	Author	Activity Description
Groundwater Remedy-Related Documents			
8/19/99	Remedial Action Monitoring Plan	Tetra Tech and MK	Guided groundwater monitoring program
6/23/00	January to March 2000 Second Quarterly Groundwater Sampling Report	Tetra Tech	Groundwater monitoring results
8/31/00	April to June 2000 Third Quarterly Groundwater Sampling Report	Tetra Tech	Groundwater monitoring results
12/22/00	September 1999 to September 2000 Annual Groundwater Sampling Report	Tetra Tech	Groundwater monitoring results
2/19/01	Distribution of the Bay Mud Aquitard and Characterization of the B-Aquifer at Parcel B	Tetra Tech	Distribution and characterization of the B-aquifer and the Bay Mud aquitard that separates the A- and B-aquifers
2/28/01	Storm Drain Infiltration Study	Tetra Tech	Investigation of storm drains as conduits for migration of contaminated groundwater, as required by the ROD; investigation found lining storm drains or grouting bedding material was not necessary
3/2/01	October to December 2000 Fifth Quarterly Groundwater Sampling Report	Tetra Tech	Groundwater monitoring results
6/1/01	January to March 2001 Sixth Quarterly Groundwater Sampling Report	Tetra Tech	Groundwater monitoring results
8/31/01	April to June 2001 Seventh Quarterly Groundwater Sampling Report	Tetra Tech	Groundwater monitoring results
11/20/01	Groundwater Evaluation Technical Memorandum	Tetra Tech	Evaluation of groundwater at Parcel B
1/22/02	July to September 2001 Eighth Quarterly Groundwater Sampling Report	Tetra Tech	Groundwater monitoring results
6/28/02	January to March 2002 Ninth Quarterly Groundwater Sampling Report	Tetra Tech	Groundwater monitoring results
11/8/02	April to June 2002 Tenth Quarterly Groundwater Sampling Report	Tetra Tech	Groundwater monitoring results
1/7/03	July to September 2002 Eleventh Quarterly Groundwater Sampling Report	Tetra Tech	Groundwater monitoring results
4/17/03	Groundwater Investigation of Hexavalent Chromium at IR-10	Tetra Tech	Investigation of the extent of chromium VI around well IR10MW12A; chromium VI not detected in samples from 10 temporary monitoring wells (Included as Appendix H)

TABLE 2-1: HISTORY OF INVESTIGATIONS SINCE ROD (CONTINUED)
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Report Date	Title	Author	Activity Description
Groundwater Remedy-Related Documents (Continued)			
5/23/03	January to December 2002 Annual Groundwater Sampling Report	Tetra Tech	Groundwater monitoring results
8/11/03	January to March 2003 Thirteenth Quarterly Groundwater Sampling Report	Tetra Tech	Groundwater monitoring results
8/22/03	April to June 2003 Fourteenth Quarterly Groundwater Sampling Report (draft)	ITSI	Groundwater monitoring results
3/8/04	July to September 2003 Fifteenth Quarterly Groundwater Sampling Report	ITSI	Groundwater monitoring results
2/20/04	January to December 2003 Sixteenth Quarterly/4th Annual Groundwater Sampling Report (draft)	ITSI	Groundwater monitoring results
10/15/04	January to March 2004 Seventeenth Quarterly Groundwater Sampling Report	Kleinfelder	Groundwater monitoring results
7/22/05	April to June 2004 Eighteenth Quarterly Groundwater Sampling Report	Kleinfelder	Groundwater monitoring results
8/19/05	July to September 2004 Nineteenth Quarterly Groundwater Sampling Report	Kleinfelder	Groundwater monitoring results
4/28/06	October to December 2004 Twentieth Quarterly/Fifth Annual Groundwater Sampling Report	Kleinfelder	Groundwater monitoring results
4/28/06	January to March 2005 Twenty-first Quarterly Groundwater Sampling Report	Kleinfelder	Groundwater monitoring results
11/1/06	April to June 2005 Twenty-second Quarterly Groundwater Sampling Report	Kleinfelder	Groundwater monitoring results
11/7/06	July to September 2005 Twenty-third Quarterly Groundwater Sampling Report	Kleinfelder	Groundwater monitoring results
10/06	October to December 2005 Quarterly Groundwater Monitoring Report and Annual Report (2005))	CE2-Kleinfelder	Groundwater monitoring results
3/07	January to March 2006 Quarterly Groundwater Monitoring Report	CE2-Kleinfelder	Groundwater monitoring results
4/07	April to June 2006 Quarterly Groundwater Monitoring Report	CE2-Kleinfelder	Groundwater monitoring results

Report Date	Title	Author	Activity Description
Groundwater Remedy-Related Documents (Continued)			
5/07	July to September 2006 Quarterly Groundwater Monitoring Report	CE2-Kleinfelder	Groundwater monitoring results
10/07	October to December 2006 Quarterly Groundwater Monitoring Report and Annual Report	CE2-Kleinfelder	Groundwater monitoring results
11/07	January to March 2007 Quarterly Groundwater Monitoring Report	CE2-Kleinfelder	Groundwater monitoring results
Treatability Study Documents			
2/14/02	Phase II Soil Vapor Extraction Treatability Study Report, Building 123, IR-10 (draft)	IT Corp.	Treatability study to evaluate soil vapor extraction for removal of TCE and other VOCs from soil beneath Building 123
8/19/03	Soil Vapor Extraction Confirmation Study Summary, Building 123, IR-10	Tetra Tech	Soil sampling confirmation study to evaluate the effectiveness of phase II SVE treatability study
6/25/04	Cost and Performance Report for Zero-Valent Iron Injection Treatability Study, Building 123	ERRG and URS	Evaluation of the performance of ZVI to treat VOCs in groundwater beneath Building 123
11/23/05	In Situ Sequential Anaerobic-Aerobic Bioremediation Treatability Study, Remedial Unit C5, Building 134, IR-25	Shaw	Evaluation of injection of lactate and hydrogen to stimulate biological dechlorination of chlorinated solvents in groundwater
11/10/06	Phase III Soil Vapor Extraction Treatability Study Report	ITSI	Expanded treatability study to evaluate soil vapor extraction for removal of TCE and other VOCs from soil beneath Building 123
Regulatory Documents			
10/7/97	Record of Decision (ROD)	Navy	Original record of decision
8/24/98	Explanation of Significant Differences	Navy	Revised remedy to include excavation to 10 feet below ground surface instead of to the groundwater table
5/4/00	Explanation of Significant Differences	Navy	Updated soil cleanup levels
12/10/03	First Five-Year Review of Remedial Actions Implemented at HPS	Tetra Tech	Assessment of whether remedy at Parcel B is or will be protective

Notes: Draft reports are listed when final reports are not yet published.

ERRG	Engineering/Remediation Resources Group, Inc.	ROD	Record of decision
HPS	Hunters Point Shipyard	TCE	Trichloroethene
IR	Installation Restoration	Tetra Tech	Tetra Tech EM Inc.
IT Corp.	International Technology Corporation	URS	URS Corporation
ITSI	Innovative Technical Solutions, Inc.	VOC	Volatile organic compound
MK	Morrison Knudsen Corporation	ZVI	Zero-valent iron
RASO	Radiological Affairs Support Office		

TABLE 2-2: RADIOLOGICALLY IMPACTED SITES

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Building/Site Number	Redevelopment Block(s)	Former Use	Current Status
103	4	Submarine barracks (1951); personnel decontamination center for Operation Crossroads personnel	Leased to San Francisco Redevelopment Agency; used by artists from The Point
113	7	Tug maintenance facility; salvage diver facility; torpedo storage and overhaul (1951-1964); sample storage from atomic weapons tests	San Francisco Police Department storage
113A	7	Torpedo storage building; nondestructive testing facility (radiography); machine and maintenance shop; shipyard analytical laboratory; radioactive material storage building; radiographer's vault; waste disposal and storage building; used to store sheet lead from Building 364	Smith-Emery
114	7	Naval Radiological Defense Laboratory design branch and technical library (1951)	Demolished
130	9, 12	Pipefitter shop; general shops; ship repair shop; machine shop; metal working shop; shop service (1968-1973); occupied by Protective Finishes Co. (1994); used by Navy for low-level radioactive waste and investigation-derived waste storage (1994)	Environmental storage
140 and discharge channel	16, BOS-3	Dry Dock 3 and pumphouse and discharge channel	Unoccupied
142	16	Air raid shelter A; storage; high-level sample counting room; low background counting room	Demolished
146	6	Industrial and photo laboratory (1951-1964); general shops; radioactive waste storage area; radioluminescent device turn-in building; tactical air navigation facility; lead-lined vault for shipyard x-ray sources	Unoccupied
157	15	Industrial laboratory; nondestructive testing; sound laboratory; testing center for metals (radiography); metal shop	Unoccupied
Dry Dock 5	BOS-2	Decontamination of ships from Operation Crossroads and ship repair (submarines)	Unused
Dry Dock 6	BOS-2	Decontamination of ships from Operation Crossroads and ship repair (submarines)	Unused
Dry Dock 7	BOS-2	Decontamination of ships from Operation Crossroads and ship repair (submarines)	Unused

TABLE 2-2: RADIOLOGICALLY IMPACTED SITES (CONTINUED)
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Building/Site Number	Redevelopment Block(s)	Former Use	Current Status
IR-07	2, 3, BOS-1	Flat land area built by the Navy to support conventional (non-nuclear) submarine maintenance; potential disposal of wastes from decontamination of ships from Operation Crossroads	Undeveloped open land
IR-18	1, 2, BOS-1	Flat land area built by the Navy; waste oil disposal area; potentially used for disposal of Operation Crossroads decontamination materials; recreational vehicle camping and parking	Undeveloped open land

Notes: Ship berths and piers at Parcel B are considered to be radiologically impacted.

IR Installation Restoration

Source:

Naval Sea Systems Command Detachment, Radiological Affairs Support Office. 2004. "Historical Radiological Assessment, Volume II, Use of General Radioactive Materials, 1939-2003, Hunters Point Shipyard." August 31.

TABLE 2-3: RAMP WELLS AND CHEMICAL EXCEEDANCES

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Well ID	Well Type	Location	Sampling Frequency	RAMP Trigger Level[a]	Date Added to RAMP	Original Install Date	Replacement Install Date	Decom-missioned Date
IR07MWS-2	POC	Near the high-tide line of the TIZ, which is the POC	Quarterly	POC	Original	09/86	06/99	--
IR07MWS-4	POC		Quarterly	POC	Original	09/86	6/99, 3/04	3/01
IR07MW19A	POC		Quarterly	POC	Original	12/90	--	--
IR10MW31A1	POC/VOC		Quarterly	POC/VOC	Original	12/93	05/99	--
IR26MW41A	POC		Quarterly	POC	Original	11/94	--	--
IR26MW45A	POC		Quarterly	POC	Original	05/99	--	2/01 [c]
IR46MW37A[c]	POC		Quarterly	POC	Original	03/94	--	--
PA50MW01A	POC/VOC		Quarterly	POC/VOC	Original	03/93	--	--
IR06MW45A	Sentinel/VOC	Near the inland edge of the approximate 5-year buffer zone	Semiannually	DAF x POC/VOC	Original	09/91	--	7/06
IR07MW23A	Sentinel		Semiannually	DAF x POC	Original	12/90	--	--
IR07MW27A	Sentinel		Semiannually	DAF x POC	Original	04/99	--	--
IR10MW28A	Sentinel/VOC		Semiannually	DAF x POC/VOC	Original	09/91	--	--
IR25MW17A	Sentinel/VOC		Semiannually	DAF x POC/VOC	Original	05/94	--	--
IR61MW05A	Sentinel		Semiannually	DAF x POC	Original	07/95	--	--
UT03MW11A	Sentinel		Semiannually	DAF x POC	Original	05/94	--	--
IR07MW20A1	Post-Remedial Action	Near remedial action excavations in IR-07	Quarterly	POC	Original	12/90	--	--
IR07MW21A1	Post-Remedial Action		Quarterly	POC	Original	12/90	3/04	3/01
IR07MW24A	Post-Remedial Action		Quarterly	POC	Original	05/99	3/04	2/01
IR07MW25A	Post-Remedial Action		Quarterly	POC	Original	05/99	3/04	11/00
IR07MW26A	Post-Remedial Action		Quarterly	POC	Original	05/99	3/04	3/01
IR10MW12A	Chromium VI/VOC	Near Building 123	Quarterly	NAWQC/VOC	Q5 [d]	12/88	--	7/06
IR10MW13A1	VOC Monitoring	In or near the VOC plume in IR-10	Quarterly	VOC	Q5	12/88	--	--
IR10MW14A	VOC Monitoring		Quarterly	VOC	Q5	01/89	--	--
IR10MW33A	VOC Monitoring		Quarterly	VOC	Original	06/99	--	--
IR10MW59A	VOC Monitoring		Quarterly	VOC	Q7	03/02	--	--
IR25MW37A	VOC Monitoring		Quarterly	VOC	Q6	11/00	--	--
IR07MW28A	On-/Off-Site Migration	Along western boundary of Parcel B	Semiannually	POC	Original	05/99	--	--
IR18MW21A	On-/Off-Site Migration		Semiannually	DAF x POC	Original	04/93	05/99	--
IR06MW42A	Utility Line	Near IR-06	Semiannually	SWPCP	Original	06/90	--	--
IR26MW46A	Supplemental	Around exploratory excavation EE-05 in IR-26	Quarterly	POC	Q9	01/02	--	--
IR26MW47A	Supplemental		Quarterly	POC	Q9	01/02	--	--
IR26MW48A	Supplemental		Quarterly	POC	Q9	01/02	--	--
IR10MW61A	Supplemental	In or near the VOC plume in IR-10	Quarterly	VOC	Q17	8/03	--	--
IR10MW62A	Supplemental		Quarterly	VOC	Q17	8/03	--	--
IR10MW71A	Supplemental		Quarterly	VOC	Q17	8/03	--	--
IR10MW76A	Supplemental		Quarterly	VOC	Q17	8/03	--	--
IR10MW79A	Supplemental		Quarterly	VOC	Q17	9/03	--	--
IR10MW80A	Supplemental		Quarterly	VOC	Q17	9/03	--	--
IR26MW49A	Supplemental	Near EE-05	Quarterly	POC	Q27	7/06	--	--
IR26MW50A	Supplemental		Quarterly	POC	Q27	7/06	--	--

Exceedances of Criteria each Quarter (Q1–Q15)

Well ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15
IR07MWS-2	*	Zn	*	*	*	*	*	*	*	*	*	*	*	*	*
IR07MWS-4	*	Ba, Zn	*	*	*	*	--	--	--	--	--	--	--	--	--
IR07MW19A	*	Ba, Zn	*	*	*	*	*	*	*	*	*	*	*	*	*
IR10MW31A1	*	Ba, Zn	*	*	*	*	*	*	*	*	*	*	*	*	*
IR26MW41A	Mn, Ni	*	*	*	*	*	*	*	*	*	*	*	*	*	*
IR26MW45A	*	Ba, Zn	*	Zn	*	*	--	--	--	--	--	--	--	--	--
IR46MW37A[c]	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
PA50MW01A	*	Zn	*	*	*	*	*	*	*	Cu, Zn	*	*	*	*	*
IR06MW45A	*	Cu, Pb, Zn	--	--	*	--	*	--	--	*	--	*	*	*	*
IR07MW23A	*	Ba, Zn	--	--	*	--	*	--	--	*	--	*	*	--	*
IR07MW27A	*	As, Ba, Zn	--	--	As	--	As	--	--	*	--	As	As	--	*
IR10MW28A	*	Ba, Zn	--	--	*	--	*	--	--	*	--	*	*	*	*
IR25MW17A	*	Zn	--	--	*	--	--	Co, Ni	--	*	--	*	*	*	*
IR61MW05A	*	Ba, Zn	--	--	*	--	*	--	--	*	--	*	*	--	*
UT03MW11A	*	Ba, Zn	--	--	*	--	*	--	--	*	--	*	*	--	*
IR07MW20A1	*	Ba, Zn	*	*	Be	*	*	*	*	*	*	*	*	*	*
IR07MW21A1	*	Ba, Zn	*	*	--	--	--	--	--	--	--	--	--	--	--
IR07MW24A	*	Ba, Zn	*	*	*	*	--	--	--	--	--	--	--	--	--
IR07MW25A	*	*	*	*	*	--	--	--	--	--	--	--	--	--	--
IR07MW26A	*	Ba, Zn	*	*	*	*	--	--	--	--	--	--	--	--	--
IR10MW12A	--	--	--	--	*	*	*	Cr VI	Cr VI	Cr VI	Cr VI	*	Cr VI	Cr VI	Cr VI
IR10MW13A1	--	--	--	--	*	*	*	*	*	*	*	*	*	*	*
IR10MW14A	--	--	--	--	*	--	*	*	*	*	*	*	*	*	*
IR10MW33A	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
IR10MW59A	--	--	--	--	--	--	TCE	TCE	TCE	TCE	TCE	TCE	TCE	TCE	TCE
IR25MW37A	--	--	--	--	--	*	*	*	*	*	*	*	*	*	*
IR07MW28A	*	Ba, Zn	*	*	*	*	*	*	*	*	*	*	*	*	*
IR18MW21A	Zn	--	--	--	--	*	*	*	*	*	*	*	*	*	*
IR06MW42A	Ba	Ba, Zn	*	*	*	*	*	*	*	*	*	*	*	*	*
IR26MW46A	--	--	--	--	--	--	--	--	*	*	*	*	*	*	*
IR26MW47A	--	--	--	--	--	--	--	--	*	Cu, Hg	Hg	Hg	*	Hg	Hg
IR26MW48A	--	--	--	--	--	--	--	--	*	*	*	*	*	*	*
IR10MW61A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IR10MW62A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IR10MW71A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IR10MW76A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IR10MW79A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IR10MW80A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IR26MW49A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IR26MW50A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sampling Date >>	Oct-Dec 1999	Jan-Mar 2000	Apr-Jun 2000	Jul-Sep 2000	Oct-Dec 2000	Jan-Mar 200	Apr-Jun 2001	Jul-Sep 2001	Jan-Mar 2002	Apr-Jun 2002	Jul-Sep 2002	Oct-Dec 2002	Jan-Mar 2003	Apr-Jun 2003	Jul-Sep 2003

Exceedances of Criteria each Quarter (Q16–Q29)

Well ID	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Number of Consecutive Rounds Below Criteria[b]
IR07MWS-2	*	Be, Tl	*	Cu, Pb	*	*	*	*	*	*	*	*	*	Cu	0
IR07MWS-4	--	*	*	Pb	Mn	*	*	*	*	*	*	*	*	*	9
IR07MW19A	*	Be, Tl	*	Be	*	*	*	*	*	*	*	Cu	*	*	2
IR10MW31A1	*	Be, Tl	*	*	*	*	*	*	*	*	*	*	*	*	12
IR26MW41A	*	*	*	--	*	*	*	*	*	*	*	*	*	*	27
IR26MW45A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2
IR46MW37A[c]	*	*	*	--	*	*	*	*	*	*	*	*	*	*	28
PA50MW01A	*	*	Ba	*	*	*	*	*	*	*	*	*	--	--	9
IR06MW45A	*	*	*	*	*	*	*	*	*	*	*	--	--	--	18
IR07MW23A	--	*	*	*	--	*	--	*	*	*	--	*	--	*	15
IR07MW27A	--	*	*	*	--	*	--	*	*	*	--	*	--	*	10
IR10MW28A	*	Cr, Pb	*	*	*	*	*	--	--	--	*	--	--	--	6
IR25MW17A	*	*	*	*	*	*	*	*	*	*	*	*	*	*	19
IR61MW05A	--	--	--	*	--	*	--	*	--	*	--	*	--	*	12
UT03MW11A	--	*	--	*	--	*	--	*	--	*	--	*	--	*	13
IR07MW20A1	*	Be, Cr	*	Be	*	*	*	*	*	*	*	Cu	*	*	2
IR07MW21A1	--	*	*	As	*	*	*	*	*	*	*	*	*	*	10
IR07MW24A	--	*	*	*	*	*	*	*	*	*	*	*	*	*	17
IR07MW25A	--	*	*	Ba, Cu, Pb	*	*	*	*	*	*	*	*	*	*	10
IR07MW26A	--	--	*	Cu, Pb	*	*	*	*	*	*	*	*	*	*	10
IR10MW12A	Cr VI	Cr VI	Cr VI	*	Cr VI	Cr VI	Cr VI	Cr VI	Cr VI	Cr VI	Cr VI	--	--	--	0
IR10MW13A1	*	*	*	*	*	*	*	*	*	*	*	*	*	*	25
IR10MW14A	*	*	*	*	*	*	*	*	*	*	*	*	*	*	24
IR10MW33A	*	*	*	*	*	*	*	*	*	*	*	*	*	--	28
IR10MW59A	TCE	*	*	*	*	*	*	*	*	*	*	*	*	DCE	0
IR25MW37A	*	*	*	*	*	*	*	--	--	--	*	*	--	*	20
IR07MW28A	*	*	*	*	*	*	*	*	*	*	*	*	*	*	27
IR18MW21A	*	*	*	*	*	*	*	*	*	*	*	*	*	*	24
IR06MW42A	*	*	*	*	*	*	*	*	*	*	*	*	*	*	27
IR26MW46A	*	*	*	*	*	*	*	*	*	*	*	*	*	*	21
IR26MW47A	Hg	Hg	Hg	Hg	Hg	As, Hg	Hg	Hg	Hg	*	*	Cu, Hg	Hg	Hg	0
IR26MW48A	*	*	*	Pb	*	*	*	Cu	*	*	*	*	*	*	6
IR10MW61A	--	*	*	VC	VC	DCE, VC	DCE	DCE, VC	*	--	*	*	*	*	5
IR10MW62A	--	*	*	*	*	*	*	*	*	--	*	*	*	*	12
IR10MW71A	--	TCE	TCE	TCE	TCE, DCE	TCE, DCE	TCE, DCE	*	*	--	*	DCE	*	*	6
IR10MW76A	--	*	*	*	*	*	*	*	*	--	*	*	*	*	12
IR10MW79A	--	*	*	*	*	*	*	*	*	--	*	*	*	*	12
IR10MW80A	--	*	*	*	*	*	*	*	*	--	*	*	*	*	12
IR26MW49A	--	--	--	--	--	--	--	--	--	--	--	*	Hg	Hg	0
IR26MW50A	--	--	--	--	--	--	--	--	--	--	--	*	*	*	3
Sampling Date >>	Oct-Dec 2003	Jan-Mar 2004	Apr-Jun 2004	Jul-Sep 2004	Oct-Dec 2004	Jan-Mar 2005	Apr-Jun 2005	Jul-Sep 2005	Oct-Dec 2005	Jan-Mar 2006	Apr-Jun 2006	Jul-Sep 2006	Oct-Dec 2006	Jan-Mar 2007	

Notes:

Two entries in the well type column indicate dual-purpose wells; for example, POC/VOC indicates well serves two purposes: VOC monitoring and POC

RAMP trigger level of DAF x POC indicates trigger level is 10 times the POC trigger level (DAF is 10); dual entries for trigger levels for dual-purpose wells

a Criteria are the HGAL, NAWQC, or VOC criteria as specified in the RAMP; the term "trigger level" in the RAMP is different than the rest of the TMSRA; trigger levels established in the RAMP will be superseded by new trigger levels in the ROD amendment that are based on the analyses presented in the TMSRA

b Rounds must be the most recent

c 37 wells are currently monitored; 40 in this list--well IR26MW45A was decommissioned and replaced by wells IR26MW46A, IR26MW47A, and IR26MW48A; IR06MW45A and IR10MW12A decommissioned

d Well IR10MW12A was added in Q5 for VOCs only, and chromium VI was added to the analytical suite in Q8

(blue) Analytical results did not exceed criteria

(yellow) Analytical results exceeded criteria

--	Not sampled	Cr VI	Hexavalent chromium	IR	Installation Restoration	ROD	Record of decision	Zn	Zinc
*	All results meet criteria	Cu	Copper	Mn	Manganese	SWPCP	Southeast Water Pollution Control Plant		
As	Arsenic	DAF	Dilution attenuation factor	Ni	Nickel	TCE	Trichloroethene		
Ba	Barium	DCE	Cis-1,2-dichloroethene	NAWQC	National ambient water quality criteria	TIZ	Tidally influenced zone		
Be	Beryllium	EE	Exploratory excavation	Pb	Lead	Tl	Thallium		
BRAC	Base Realignment and Closure	Hg	Mercury	POC	Point of compliance	TMSRA	Technical memorandum in support of a record of decision amendment		
Co	Cobalt	HGAL	Hunters Point groundwater ambient level	Q1, Q2, etc.	First quarter of RAMP, second quarter of RAMP, etc.	VC	Vinyl chloride		
Cr	Chromium	ID	Identification	RAMP	Remedial action monitoring program	VOC	Volatile organic compound		

TABLE 2-4: SUMMARY OF CHEMICALS REMAINING IN SOIL AT PARCEL B

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Site Name[a]	Redevelopment Block(s)	Site Description	Chemicals of Concern[b]	Possible Sources[c]	Volume of Contaminated Soil Removed[d] (Cubic Yards)
IR-07	2, 3, BOS-1	Sub-Base Area	Metals, SVOCs, and PCBs	Disposal of sandblast waste, disposal of waste oil at IR-07 and IR-18, and bedrock-derived fill	52,500
IR-10	8	Building 123 (Battery and Electroplating Shop)	Metals, VOCs, SVOCs, and PCBs	Naturally occurring or anthropogenic metals, releases of waste acids and plating solutions into the floor drains inside Building 123, leaks from acid drain lines	1,400
IR-18	1, 2, BOS-1	Waste Oil Disposal Area	Metals, SVOCs, and PCBs	Disposal of waste oil containing lead or placement of lead-contaminated fill material, disposal of waste oil, and bedrock-derived fill	22,000
IR-20	12	Building 156 (Rubber Shop)	Metals, VOCs, SVOCs, and PCBs	Naturally occurring or anthropogenic metals and storage of waste oils and chemicals in Building 156	3,100
IR-23	5, 6, BOS-1, BOS-2	Building 146 (Tactical Air Navigation Facility), Building 161 (Maintenance Service), Building 162 (Paint Storage), and Tank S-136	Metals, VOCs, SVOCs, and PCBs	Petroleum hydrocarbon surface spill and naturally occurring or anthropogenic metals	2,800
IR-24	9, 12, BOS-2	Building 124 (Acid Mixing Plant), Building 125 (Submarine Cafeteria), and Buildings 128 and 130 (Machine Shop)	Metals, VOCs, SVOCs, and PCBs	Naturally occurring or anthropogenic metals, lead-containing fuel and waste paint, releases of diesel fuel and lubrication oil along the distribution pipelines that make up IR-46, and leakage of fuel from the fuel distribution lines	4,200
IR-26	15, 16, BOS-3	Building 157 (Nondestructive Testing Laboratory) and Area XIV	Metals, VOCs, SVOCs, and PCBs	Naturally occurring or anthropogenic metals and petroleum-related contamination	7,500
IR-42	7	Building 109 (Police Station), Building 113 (Tug Maintenance Shop and Salvage Divers Shop), and Building 113A (Machine Shop, Torpedo Maintenance Shop, Tug Maintenance Shop, and Electrical Substation)	Metals, SVOCs, and PCBs	Naturally occurring or anthropogenic metals and petroleum-related contamination	300
IR-46 (Fuel Lines)	9, 12, BOS-2	Fuel Distribution Lines	Metals, SVOCs, and PCBs	Naturally occurring or anthropogenic metals, releases from fuel line system, spilled fuel or oil from tanks and distribution pipelines, diesel fuel and lube oil pipelines (and waste fuel and oil lines), and other petroleum-related contamination	19,100

TABLE 2-4: SUMMARY OF CHEMICALS REMAINING IN SOIL AT PARCEL B (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Site Name[a]	Redevelopment Block(s)	Site Description	Chemicals of Concern[b]	Possible Sources[c]	Volume of Contaminated Soil Removed[d] (Cubic Yards)
IR-60	BOS-2	Dry Docks 5, 6, and 7	Metals and SVOCs	Naturally occurring or anthropogenic metals and ship painting activities	600
IR-61	6	Building 122 (Electrical Substation V and Compressor Plant)	Metals and PCBs	Naturally occurring or anthropogenic metals and transformer release of PCBs	100
IR-62	4, 5	Buildings 115 and 116, Submarine Training Buildings and School	None[e]	Not applicable	Not applicable
SI-31	7	Building 114, Offices	None[e]	Not applicable	Not applicable
SI-45	7	Steam Line System	None[e]	Not applicable	Not applicable

Notes:

a IR-06 is not included in this table because it will be addressed as part of Parcel C and will be evaluated in future 5-year reviews that follow a Parcel C ROD. Although portions of IR-50 (storm drain and sanitary sewer systems) and IR-51 (former transformer sites) within Parcel B are addressed by the Parcel B ROD, information on contamination associated with these sites is presented with the IR sites that contain the contamination associated with IR-50 and IR-51.

b Chemical groups listed include chemicals evaluated in the human health risk assessment; these chemicals also exceed the remedial action objectives defined in the ROD (Navy 1997) and subsequent ESDs (Navy 1998, 2000).

c Sources listed were identified in the Parcel B remedial investigation and feasibility study (PRC, HLA, Levine-Fricke, and Uribe and Associates 1996; PRC 1996), and information gathered during the remedial action.

d Volumes of contaminated soil are based on the volumes excavated according to the construction summary report (Tetra Tech 2002a), addendum (SulTech 2004), TPH closeout report (TPA-CKY Joint Venture 2005), and other estimates from remedial action activities.

e No chemicals were detected at levels that exceed remedial action objectives defined in the ROD (Navy 1997) and subsequent ESDs (Navy 1998, 2000). IR-62 contained only fuel-related contamination that was not commingled with chemicals identified in the ROD and ESDs.

ESD	Explanation of significant difference	PRC	PRC Environmental Management, Inc.	Tetra Tech	Tetra Tech EM Inc.
HLA	Harding Lawson Associates	ROD	Record of decision	TPH	Total petroleum hydrocarbons
IR	Installation Restoration	SI	Site inspection	VOC	Volatile organic compound
PCB	Polychlorinated biphenyl	SVOC	Semivolatile organic compound		

Sources:

Navy. 1997. "Hunters Point Shipyard, Parcel B, Record of Decision." November 16.

Navy. 1998. "Explanation of Significant Difference, Naval Station Treasure Island, Hunters Point Annex." August 24.

Navy. 2000. "Final Explanation of Significant differences, Parcel B, Hunters Point Shipyard, San Francisco, California." May 4.

PRC. 1996. "Parcel B Feasibility Study Final Report, Hunters Point Shipyard, San Francisco, California." November 26.

PRC, HLA, Levine-Fricke, and Uribe & Associates. 1996. "Parcel B Remedial Investigation, Draft Final Report, Hunters Point Shipyard, San Francisco, California." June 3.

SulTech. 2004. "Draft Parcel B Construction Summary Report Addendum, Hunters Point Shipyard, San Francisco, California." September 8.

Tetra Tech. 2002a. "Draft Parcel B Construction Summary Report, Hunters Point Shipyard, San Francisco, California." November 18.

TPA-CKY Joint Venture. 2005. "Draft Final Site Closeout Report, Total Petroleum Hydrocarbon Program Corrective Action Implementation Soil Removal for Parcels B, C, D, and E, Hunters Point Shipyard, San Francisco, California." June.

3.0 UPDATED RISK EVALUATION SUMMARY AND REMEDIATION GOALS

This section summarizes the potential human health and ecological risks from exposure to chemicals at Parcel B, identifies COCs for human health and ecological endpoints, and presents remediation goals for the identified COCs. Human health risks were evaluated for exposure to soil and groundwater, while ecological risks were evaluated for exposure to sediment and groundwater. The updated characterization of soil, groundwater, and sediment at Parcel B is presented in Section 2.0.

3.1 HUMAN HEALTH RISK ASSESSMENT

A revised baseline HHRA was conducted for Parcel B. The objectives of the revised HHRA were to:

- Estimate the potential risks to human health associated with potential future land use scenarios
- Identify the environmental media and contaminants that pose the primary health concerns
- Identify the environmental media and contaminants that are likely to pose little or no threat to human health
- Provide a foundation for assessing the need for further response actions

The original HHRA for Parcel B was conducted in 1996 (PRC and others 1996) as part of the RI. This HHRA was the basis for the 1997 ROD, RD, and subsequent excavations in 1998 and 1999. The Navy revised the original HHRA in 2000 to update cleanup goals for Parcel B; these revised goals were then presented in an ESD (see Section 2.1.5). The Navy revised the RD and conducted a second round of remedial action excavations during 2000 to 2001. All these additional remedial action data were incorporated into a revised HHRA, released in January 2003. An additional soil removal in 2004 and 2005 resulted in additional excavation and data collection. This HHRA revises the 2003 HHRA to account for the data collected during the 2004 and 2005 removals as well as updates to EPA toxicity values and exposure assumptions. Data associated with sample locations excavated and removed during the activities in 1998 to 2001 and 2004 to 2005 are excluded from this HHRA. The HHRA in this TMSRA was completed before the start of the radiological removal actions at Parcel B; consequently, some samples included in the HHRA have since been excavated and removed. The inclusion of these samples adds another measure of conservatism to the HHRA. In addition, data for groundwater collected up to and including quarter 20 (October to December 2004) as part of the Parcel B RAMP at HPS are included in this HHRA. Lastly, the HHRA was revised based on BCT agreements during 2003 and 2004.

The HHRA calculated cancer risks and noncancer hazards from exposure to chemicals of potential concern (COPC) in all affected environmental media for each pathway identified as potentially complete. Appendix A details the HHRA methodology and results. This section provides an overview of the exposure scenarios and pathways evaluated in the HHRA and summarizes the results of the HHRA. In addition, remediation goals are presented for the COCs for Parcel B, as identified from the results of the HHRA. COPCs are identified as COCs when the chemical-specific risk exceeds 1E-06 or the noncancer hazard exceeds 1.0.

3.1.1 Exposure Scenarios and Pathways

The redevelopment plan outlines the planned reuses for Parcel B (San Francisco Redevelopment Agency 1997). Parcel B was divided into redevelopment blocks to help identify the areas of Parcel B associated with specific planned reuses. Each redevelopment block was then assigned a number. Figure 3-1 shows the locations of each of the redevelopment blocks assigned to Parcel B, the associated number, and the specific planned reuse. According to the redevelopment plan, most of the planned reuse for Parcel B is mixed use and research and development (San Francisco Redevelopment Agency 1997) which is evaluated in the HHRA assuming residential reuse. Other planned reuses of Parcel B include educational/cultural (industrial reuse) and open space (recreational reuse). The table below summarizes the planned reuses for each redevelopment block at Parcel B.

Redevelopment Block	Planned Reuse	Associated Exposure Scenario for HHRA
1	Mixed Use	Residential
2	Research and Development	
3	Research and Development	
4	Mixed Use	
5	Research and Development	
6	Research and Development	
7	Mixed Use	
8	Mixed Use	
9	Mixed Use	
12	Mixed Use	
15	Mixed Use	
16	Educational/Cultural	Industrial
BOS-1	Open Space	Recreational
BOS-2	Open Space	
BOS-3	Open Space	

The following receptors were selected for evaluation in the HHRA for Parcel B based on the planned reuses for Parcel B and the likelihood that excavation and trenching will be required to develop Parcel B for the planned reuses:

- Resident (adult and child)
- Industrial worker (adult)
- Recreational user (adult and child)
- Construction worker (adult)

Table 3-1 presents an exposure matrix that summarizes the exposure pathways identified as potentially complete for each of these receptors. Both direct exposure pathways (for example, ingestion) and indirect exposure pathways (for example, ingestion of home-grown produce) for soil and groundwater were identified as potentially complete (see Table 3-1). Residential exposure to groundwater in the A-aquifer from domestic use (such as ingestion) was not evaluated in the HHRA because the A-aquifer at HPS is not considered a potential source of drinking water (see Section 2.2). The evaluation of the B-aquifer suggests that it has a low potential as a source of drinking water. However, the groundwater ingestion pathway is included in the HHRA for the B-aquifer groundwater because of agreements with the BCT on the methodology for the HHRA, and because the groundwater in the B-aquifer has not been exempted from the potential municipal and domestic beneficial uses specified in the Water Quality Control Plan for the San Francisco Bay Region. This assumption provides an additional measure of conservatism in protection of human health at HPS.

The HHRA divided each redevelopment block at Parcel B into 0.5-acre exposure areas (approximately 150 feet by 150 feet) and 2,500-square-foot exposure areas. The BCT and City of San Francisco selected the 0.5-acre exposure area as a reasonable estimate for a light industrial lot in the San Francisco Bay area. The BCT selected the 2,500-square-foot exposure area as a reasonable estimate for a residential lot because it is a minimum residential lot size for a single-family home allowed by the San Francisco planning code (City and County of San Francisco 1995). This HHRA refers to each 0.5-acre exposure area at Parcel B as an "industrial grid" and to each 2,500-square-foot exposure area as a "residential grid." Each grid was assigned a unique identification number, referred to as the "grid number."

Risks from exposure to soil were evaluated for each grid where sampling data are available and the sampling locations have not been subject to removal actions. Residential grids were used to assess residential exposures, while industrial grids were used to assess industrial, recreational, and construction worker exposures.

Risks from exposure to COPCs in groundwater were assessed for the A- and B-aquifers. For the A-aquifer, residential and industrial exposure to groundwater from inhalation of volatile COPCs in groundwater that migrate through the subsurface to indoor air (vapor intrusion) is the only complete exposure pathway for the planned reuses of Parcel B. For this HHRA, mercury in groundwater is considered volatile but mercury in soil is not (see Section A5.1.3.2 of Appendix A for more detail). Mercury in groundwater is considered volatile because mercury may dissolve in groundwater and partition from an aqueous to a gaseous phase. When present in soil, partitioning of mercury to a gaseous phase is minimal because mercury in soil complexes with anions and forms mercury compounds with limited mobility and volatility (refer to Appendix A for additional information).

For the construction worker scenario, exposure to groundwater in the A-aquifer may occur during trenching activities. Residential exposure to groundwater in the A-aquifer from domestic use (such as ingestion) was not evaluated in the HHRA because the A-aquifer at HPS is not considered a potential source of drinking water (see Section 2.0). However, because groundwater in the B-aquifer is considered to be a low potential source of drinking water, residential exposure to groundwater was evaluated for the B-aquifer.

Risks from residential, industrial, and construction worker exposure to groundwater in the A-aquifer were assessed for three risk plume-based exposure areas: the IR-10A risk plume, the IR-10B risk plume, and the IR-25 risk plume. These risk plumes are present in the A-aquifer only. The risk plumes were developed using a specific methodology developed for the HHRA based on agreements made with the BCT (see Attachment A4, Figures A4-1 through A4-3). The risk plumes are based on historical and more recent data, incorporating the 12 most recent sampling results for each analyte at each well. Groundwater data collected at Parcel B through November 2004 were used to delineate these risk plumes. Because this methodology includes historical data more than 10 years old, the risk plumes reflect a worst-case scenario of groundwater contamination. Current conditions differ from the risk plumes. The IR-10A and IR-25 risk plumes are based on delineation of VOC concentrations to respective laboratory reporting limits. The IR-10B risk plume is based on delineation of chromium VI concentrations to the laboratory reporting limit for chromium VI. Chemical concentrations measured from some groundwater monitoring locations at Parcel B were not associated with risk plumes; these nonplume-based locations were evaluated on a grid basis, using the same grid system that was used in the HHRA to evaluate soil exposures as an efficient mechanism to locate each nonplume risk evaluation.

Risks from exposure to COPCs in soil and groundwater for each redevelopment block were evaluated both for the specific exposure scenario associated with the planned reuse of the redevelopment block, and for the other potential exposure scenarios identified for Parcel B, regardless of the planned reuse of the redevelopment block. Using this approach, risks for each redevelopment block were evaluated for residential, industrial, recreational, and construction worker exposures. The HHRA results summarized in this section are for the specific planned reuse of each redevelopment block. For groundwater in the B-aquifer, which was evaluated for residential exposure from domestic use, HHRA results are based on each exposure area evaluated, regardless of planned reuse. Risks associated with construction worker exposure at each redevelopment block are also summarized in this section, as exposures under this scenario may occur regardless of the planned reuse of the redevelopment block. Appendix A contains the risk results for all exposure scenarios evaluated for each redevelopment block.

3.1.2 Total and Incremental Risks for Exposure to Soil

Both total and incremental risks were evaluated for exposure to soil at Parcel B. All detected chemicals were included as COPCs for the total risk evaluation, regardless of concentration, except for the essential nutrients calcium, magnesium, potassium, and sodium. The total risk evaluation provides an estimate of the risks posed by all chemicals at the site, including any present at concentrations at or below ambient levels. Conversely, the essential nutrients and metals with maximum measured concentrations below HPALs were excluded as COPCs for the incremental risk evaluation. The incremental risk evaluation provides an estimate of risks posed by all chemicals at the site, except any that do not exceed ambient levels.

3.1.3 Risk Summary for Soil

This section summarizes the results of the total and incremental risk evaluations for soil, based on planned reuse.

3.1.3.1 Total Risk Evaluation

Risks from exposure to COPCs in soil were assessed for the total risk evaluation for both surface soil (0 to 2 feet bgs) and subsurface soil (0 to 10 feet bgs). Figures 3-2 and 3-3 summarize the grid-specific total risk results for surface and subsurface soil based on the planned reuse of the redevelopment block associated with each grid. Figure 3-4 summarizes the grid-specific total risk results for construction worker exposure to soil. The results for each grid are shown relative to the cancer risk threshold of 1E-06, highest segregated noncancer HI threshold of 1.0, and HPS risk-based concentration for lead (155 mg/kg for residential and recreational receptors and 800 mg/kg for industrial and construction worker receptors). The specific calculated total cancer risk and noncancer HI results for each grid are listed in Tables 3-2, 3-3, and 3-4. The risk results shown in the figures and tables represent total risk; that is, all detected chemicals that are not considered essential human nutrients were included in the risk evaluation.

Tables 3-5, 3-6, and 3-7 present a risk characterization analysis for grids where the total cancer risk exceeds 1E-06 or the highest segregated HI exceeds 1.0. The tables identify the COCs for each of these grids and present their contribution to the calculated total risks and hazards for each potentially complete exposure pathway.

The following chemicals are identified as COCs in at least one grid, based on planned reuse and results of the total risk evaluation for soil.

Exposure Scenario	Chemicals of Concern in Surface Soil, Total Risk	Chemicals of Concern in Subsurface Soil, Total Risk
Industrial[1]	None	Arsenic, Benzo(a)anthracene, and Benzo(a)pyrene
Recreational[1]	Aroclor-1254, Aroclor-1260, Arsenic, Benzo(a)pyrene, and Lead	Not applicable
Residential[1]	Antimony, Arsenic, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, bis(2-Ethylhexyl)phthalate, Copper, Dibenz(a,h)anthracene, Dieldrin, Heptachlor Epoxide, Indeno(1,2,3-cd)pyrene, Iron, Lead, Manganese, Nickel, Tetrachloroethene, Trichloroethene, Vanadium, and Zinc	Antimony, Aroclor-1254, Aroclor-1260, Arsenic, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, beta-BHC, bis(2-Ethylhexyl)phthalate, Cadmium, Copper, Dibenz(a,h)anthracene, Dieldrin, Heptachlor Epoxide, Indeno(1,2,3-cd)pyrene, Iron, Lead, Manganese, Mercury, Naphthalene, Nickel, Tetrachloroethene, Trichloroethene, Vanadium, and Zinc
Construction Worker[2]	Not applicable	Aroclor-1260, Arsenic, Benzo(a)pyrene, Lead, and Trichloroethene

Notes:

1 Chemicals of concern identified for this exposure scenario are based on the planned reuse for Parcel B. No chemicals of concern were identified for exposure of industrial workers to surface soil.

2 The construction worker exposure scenario is not associated with a specific planned reuse for Parcel B. Based on discussions and an agreement with the BCT, evaluation of construction worker exposure to soil was based on subsurface soil from 0 to 10 feet bgs; this depth range includes surface soil (0 to 2 feet bgs) exposure.

BHC Benzene hexachloride

3.1.3.2 Incremental Risk Evaluation

Risks from exposure to COPCs in soil were assessed for both surface soil (0 to 2 feet bgs) and subsurface soil (0 to 10 feet bgs) for the incremental risk evaluation. Figures 3-5 and 3-6 summarize the grid-specific incremental risk results for surface and subsurface soil based on the planned reuse of the redevelopment block associated with each grid. Figure 3-7 summarizes the grid-specific incremental risk results for construction worker exposure to soil. The specific calculated incremental cancer risk and noncancer HI results for each grid are listed in Tables 3-8, 3-9, and 3-10. The risk results shown in the figures and tables represent incremental risk; that is, all detected chemicals except essential human nutrients and metals below HPALs were included in the risk evaluation.

Tables 3-11, 3-12, and 3-13 present a risk characterization analysis for grids where the incremental cancer risk exceeds 1E-06 or highest segregated HI exceeds 1.0. For each of these grids, the tables identify the COCs and present their contribution to the calculated incremental risks and hazards for each potentially complete exposure pathway.

The following chemicals are identified as COCs in at least one grid, based on planned reuse and the results of the incremental risk evaluation for soil. Approximately 71 percent of the grids identified in the total risk evaluation for surface soil as having a cancer risk that exceeds 1E-06 or a noncancer HI greater than 1.0, no longer exceed those risk thresholds following the incremental risk evaluation. Similarly, approximately 45 percent of the grids identified in the total risk evaluation for subsurface soil as having exceedances no longer exceed the cancer and noncancer risk thresholds following the incremental risk evaluation.

Exposure Scenario	Chemicals of Concern in Surface Soil, Incremental Risk	Chemicals of Concern in Subsurface Soil, Incremental Risk
Industrial[1]	None	Arsenic, Benzo(a)anthracene, and Benzo(a)pyrene
Recreational[1]	Aroclor-1254, Aroclor-1260, Arsenic, Benzo(a)pyrene, and Lead	Not applicable
Residential[1]	Antimony, Arsenic, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, bis(2-Ethylhexyl)phthalate, Copper, Dibenz(a,h)anthracene, Dieldrin, Heptachlor Epoxide, Indeno(1,2,3-cd)pyrene, Lead, Manganese, Tetrachloroethene, Trichloroethene, and Zinc	Antimony, Aroclor-1254, Aroclor-1260, Arsenic, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, beta-BHC, bis(2-Ethylhexyl)phthalate, Cadmium, Copper, Dibenz(a,h)anthracene, Dieldrin, Heptachlor Epoxide, Indeno(1,2,3-cd)pyrene, Iron, Lead, Manganese, Naphthalene, Tetrachloroethene, Trichloroethene, Vanadium, and Zinc
Construction Worker[2]	Not applicable	Aroclor-1260, Arsenic, Benzo(a)pyrene, Lead, and Trichloroethene

Notes:

1 Chemicals of concern identified for this exposure scenario are based on the planned reuse for Parcel B.

2 The construction worker exposure scenario is not associated with a specific planned reuse for Parcel B.

BHC Benzene hexachloride

3.1.4 Risk Summary for Groundwater

Risks from exposure to COPCs in groundwater were assessed for the A- and B-aquifers. Three plumes were identified for Parcel B that present a potential risk to human health: the IR-10A plume, the IR-10B plume, and the IR-25 plume. Exposure to groundwater from inhalation of volatile COPCs in groundwater that migrates through the subsurface to indoor air (vapor intrusion) is the only complete exposure pathway for the A-aquifer for the planned reuses of Parcel B. Exposure to A-aquifer groundwater may occur during trenching for the construction worker scenario. Figure 3-8 summarizes the risk results for groundwater for each of the identified plumes and non-plume exposure areas in the A-aquifer based on the planned reuse for each redevelopment block. Figure 3-9 summarizes the risk results for exposure to groundwater in the B-aquifer. The risk results for groundwater in the B-aquifer, which was evaluated for residential exposure from domestic use, are based on each exposure area evaluated, regardless of planned reuse. Figure 3-10 summarizes the risk results for construction worker exposure to groundwater for both plume- and non-plume-based exposures. The results in the figures are shown compared with the cancer risk threshold of 1E-06 and the highest segregated noncancer HI of 1.0.

Tables 3-14, 3-15, and 3-16 present a groundwater risk characterization analysis for exposure areas where the cancer risk exceeds 1E-06 or the highest segregated HI exceeds 1.0 for the exposure scenarios associated with planned reuse of the A-aquifer, domestic use of the B-aquifer, and for the construction worker scenario. These tables identify the groundwater COCs associated with each plume in Parcel B and the percent contribution of each COC to the total cancer risk and HI calculated for each plume. Exposure areas that are not associated with plumes that contain COCs are also shown on Tables 3-14, 3-15, and 3-16. The following chemicals are identified as COCs in groundwater in the A-aquifer based on planned reuse.

Exposure Scenario	Chemicals of Concern in Groundwater, A-Aquifer		
Industrial[1]		Chloroform	
Recreational[1]		Not applicable	
Residential[1]	1,2,4-Trichlorobenzene 1,2,4-Trimethylbenzene 1,2-Dichlorobenzene 1,2-Dichloroethane 1,2-Dichloroethene (total) 1,2-Dichloropropane1,3,5-Trimethylbenzene 1,4-Dichlorobenzene	Chloroethane Chloroform cis-1,2-Dichloroethene 2-Methylnaphthalene[2] Benzene Bromodichloromethane Chlorobenzene Dichlorodifluoromethane	Methylene chloride Naphthalene Tetrachloroethene trans-1,2-Dichloroethene Trichloroethene Trichlorofluoromethane Vinyl chloride
Construction Worker[3]	1,2,4-Trichlorobenzene 1,2,4-Trimethylbenzene 1,2-Dichlorobenzene 1,2-Dichloroethane 1,2-Dichloroethene (total) 1,2-Dichloropropane 1,4-Dichlorobenzene 2,4,6-Trichlorophenol 2,4-Dimethylphenol 2,4-Dinitrotoluene	2-Methylnaphthalene 4-Methylphenol Arsenic Benzene Benzo(a)anthracene Benzo(a)pyrene Bromodichloromethane Chlorobenzene Chloroform[2]	Chrysene cis-1,2-Dichloroethene Mercury[2] Naphthalene Pentachlorophenol Tetrachloroethene trans-1,2-Dichloroethene Trichloroethene Vinyl chloride

Notes:

1 Chemicals of concern identified for this exposure scenario are based on the planned reuse for Parcel B.
2 Chemical is a COC based on the maximum concentration scenario (see Sections A5.1.2 and A8.0 of Appendix A).
3 The construction worker exposure scenario is not associated with a specific planned reuse for Parcel B.

Exposure areas that are not associated with plumes that contain COCs are shown on Tables 3-14, 3-15, and 3-16. Three individual locations (grids B1528, B4516, and AY04) resulted in potential unacceptable risks caused by vapor intrusion from groundwater in the A-aquifer. Section 3.4 contains more detailed discussion of these three grids.

The B-aquifer is predominantly absent from most areas of Parcel B except the western portion of the parcel. Exposure areas evaluated for domestic use exposure to groundwater in the B-aquifer were limited to two non-plume exposure areas in Redevelopment Block 2, and two non-plume exposure areas in Redevelopment Block BOS-1. Because the potential for hydraulic communication between the A- and B-aquifers exists in the western portion of Parcel B, the HHRA evaluated potential risks from domestic use of groundwater under two cases: first using solely B-aquifer data, and second using a combination of B- and A-aquifer data, when available, to account for potential hydraulic communication between the two aquifers in some areas of Parcel B. The risk characterization analysis and identification of B-aquifer COCs presented in Table 3-15 were limited to risk results that account for potential hydraulic communication between the A- and B-aquifers because these results provide a more conservative estimate of potential risks from exposure to the B-aquifer (that is, risks evaluated for the B-aquifer using a combination of A- and B-aquifer data result in more COCs than risks evaluated using solely B-aquifer data). COCs for the B-aquifer were identified for grids B0139, B0237, and B0238 and are summarized below.

Exposure Scenario	COCs in Groundwater, B-Aquifer[1]	
Residential	1,4-Dichlorobenzene Antimony Arsenic Benzene Chloroethane	Manganese Pentachlorophenol Thallium Trichloroethene

Note:

1 COCs in the B-aquifer are identified based on evaluation of risks using a combination of A- and B-aquifer data, when available, to account for potential hydraulic communication in some areas of Parcel B.

The HHRA did not include characterization of potential risks from residential domestic use of groundwater for the A-aquifer plume areas (IR-10A, IR-10B, IR-25) because the B-aquifer either was not present or was present only to a limited extent in the location of these plumes. Therefore, it was assumed that the A-aquifer was not in hydraulic communication with the B-aquifer in these areas. Nevertheless, risks from residential domestic use of groundwater in each of the A-aquifer-plume areas were calculated, as part of the analysis of potential uncertainties associated with the HHRA, assuming that hydraulic communication occurs and pumping groundwater in the B-aquifer results in transport of chemicals detected in the A-aquifer downward into the B-aquifer. The results of this analysis, detailed in Section A9.8, show that residential domestic use cancer risks for each of the plume-based exposure areas exceeds the threshold of 1E-06 and noncancer hazards exceed the threshold of 1.0. Section A9.8 in Appendix A contains additional discussion of risks posed by potential communication between the A- and B-aquifers at Parcel B.

3.2 ECOLOGICAL EVALUATION

The majority of Parcel B, approximately 75 percent, is covered by pavement and buildings. With little open space for flora and fauna, Parcel B is considered to have insignificant habitat value and poses an insignificant risk to terrestrial ecological receptors. Exposure pathways to terrestrial species are incomplete because of a lack of habitat and the predominance of paved areas in Parcel B (PRC 1996). However, potential ecological risk to receptors near the shoreline was not previously evaluated. The SLERA presented in Appendix B and further discussed below evaluates potential ecological risks from exposure to shoreline sediment and exposure to groundwater as it interacts with surface water. Contaminants in shoreline sediment could result from overland transport of soil by runoff or by erosion of the shoreline and exposure of underlying soil. Contaminants in groundwater could migrate and interact with surface water at the shoreline.

The focus of the SLERA is the intertidal zone of the Parcel B shoreline, which incorporates portions of IR-07 and IR-26. The shoreline of IR-07 consists of about 1.5 acres and includes approximately 1,300 square feet of tidal marsh wetlands. A detailed description of the wetlands can be found in the Wetlands Delineation and Functions and Values Assessment report (Tetra Tech 2002b). The shoreline of IR-26 consists of about 0.3 acre on the Point Avisadero peninsula. Field observations found that mainly invertebrates and birds use the shoreline habitat. Invertebrates included crabs and isopods that hide under rocks and feed on other small invertebrates. Mussels and barnacles are visible on the rocks at low tide.

The SLERA considered exposures to the following ecological receptor groups in the evaluation of the Parcel B shoreline:

- Benthic invertebrates
- Diving ducks (represented by the surf scoter)
- Carnivorous shorebirds (represented by the willet)
- Carnivorous birds (represented by the red-tailed hawk)
- Omnivorous small mammals (represented by the house mouse)

Exposures to benthic invertebrates were evaluated by direct comparison of chemical concentrations in sediment to a benchmark value (the effects range-median [ER-M]). Exposures to birds and mammals were assessed based on calculating daily ingested chemical doses using food chain modeling and comparison of site-specific ingested doses of chemicals to toxicity reference values. Dose calculations incorporate several types of data, including (1) chemical concentrations in sediment, (2) estimated prey tissue concentrations based on biotransfer factors from terrestrial areas of Parcel E (Battelle and others 2002; Tetra Tech and LFR 2000; EPA 1999c), (3) ecological field studies, and (4) the natural history of selected receptors.

Although chemical concentrations in groundwater will be diluted when they enter the bay, the SLERA used the maximum concentrations detected in groundwater as conservative estimates to select chemicals of potential ecological concern, in accordance with EPA guidance (EPA 1997c). Risks to aquatic receptors from chemicals in groundwater were evaluated by directly comparing groundwater concentrations to these screening criteria. Additional lines of evidence used in refining chemicals of potential ecological concern in groundwater included frequency and magnitude of detections in samples collected from 16 Parcel B shoreline wells over the 12 most recent sampling events.

The data presented in Appendix B indicate potential unacceptable risk to benthic invertebrates, birds, and mammals from several metals, pesticides, and PCBs in sediment along the Parcel B shoreline. Likewise, data in Appendix B indicate potential unacceptable risk may be caused by concentrations of mercury, which was identified as a COC in groundwater. VOCs in groundwater were not found to pose a risk to San Francisco Bay. The following COCs were identified for ecological exposure at Parcel B:

Chemicals of Concern in Sediment	Chemical of Concern in Groundwater
Aluminum, Copper, Dibenz(a,h)anthracene, Dieldrin, Lead, Methoxychlor, Total Aroclors, Total Dichlorodiphenyltrichloroethane, and Zinc	Mercury

In summary, some potentially toxic chemicals were detected in sediment and groundwater at the Parcel B shoreline at concentrations that exceed ambient levels and toxicological benchmarks, with exposure pathways to receptors that are complete.

3.3 REMEDIATION GOALS AND GROUNDWATER TRIGGER LEVELS

Remediation goals were developed for the COCs identified for soil, groundwater, and sediment using the methodology described below. The development of remediation goals was limited to the COCs identified based on the incremental risk evaluation, which excludes the risks posed by metals at concentrations below ambient levels. Remediation goals for groundwater were developed based on the results of the HHRA, accounting for Hunters Point groundwater ambient levels (HGAL). Remediation goals for sediment were developed based on the results of the SLERA.

Surface water quality was evaluated to assess whether groundwater was affecting the bay. Chemical-specific trigger levels were developed for this pathway to identify potential risks to the surface water of the bay. The trigger levels are unique to each source, primarily based on the source width and the distance from the source to the bay, and are a means of relating the surface water quality criteria to groundwater. As explained below, the trigger levels provide a means to identify when further studies or remedial action may be required to protect the bay.

3.3.1 Soil

Remediation goals for COCs in soil were selected based on a comparison of the COC-specific risk-based concentration (RBC), the laboratory practical quantitation limit (PQL) based on standard EPA analytical methods, and the HPAL (metals only). The highest of these three concentrations was selected as the remediation goal for soil for each COC. Exposure scenario-specific risk-based concentrations were calculated based on a target cancer risk level of 1E-06 and target noncancer HI of 1.0, consistent with the exposure pathways and assumptions used to assess risks. Table 3-17 presents the remediation goals for COCs in soil.

3.3.2 Groundwater

Remediation goals for COCs in groundwater in the A- and B-aquifers are shown in Tables 3-18 and 3-19. Development of the remediation goals for groundwater was based on consideration of chemical-specific ARARs identified for the A- and B-aquifers, exposure scenario-specific RBCs, laboratory PQLs, and HGALs (for metals only). Chemical-specific ARARs are discussed further and identified in Section 4.2. Exposure scenario-specific screening levels based on a target cancer risk level of 1E-06 and a target noncancer HI of 1.0 were used as RBCs for groundwater. The RBCs for A-aquifer COCs for the residential and industrial scenarios were based on inhalation of volatile chemicals from groundwater. The RBCs for A-aquifer COCs for the construction worker scenario were based on dermal contact with and vapor inhalation of A-aquifer groundwater. For the B-aquifer, the RBCs were based on residential domestic use of groundwater.

For organic COCs, the chemical-specific ARAR is used as the remediation goal, when available. In the absence of chemical-specific ARARs, the chemical-specific RBC is used as the remediation goal for organic COCs. However, the remediation goal defaults to the laboratory PQL if the ARAR- or RBC-based concentration is lower than the PQL, because the ARAR or RBC would not be detectable at concentrations below the PQL. For inorganic chemicals, this same hierarchy applies for selection of remediation goals except that the HGAL (metals only) is selected as the remediation goal if it exceeds either the chemical-specific ARAR or the RBC, and is greater than the laboratory PQL.

3.3.3 Sediment

Remediation goals for COCs in sediment, as identified by the SLERA, were selected based on a comparison of the COC-specific ecological RBC, the PQL, and the HPAL (metals only). The highest of these concentrations was selected as the remediation goal for sediment for each COC. Ecological RBCs were calculated based on the methodologies described in the SLERA (see Appendix B). These methodologies include back calculation of concentrations using dose modeling, as well as comparison to ER-M values (Long and others 1995) and ambient concentrations (Water Board 1998). Table 3-20 presents the remediation goals for COCs in sediment.

3.3.4 Groundwater Trigger Levels

Groundwater at Parcel B is in contact with the surface water of the bay. A screening evaluation was performed to assess whether the concentrations of chemicals detected in the groundwater could affect the surface water of the bay. This evaluation involved comparison of surface water quality criteria with detected concentrations in the groundwater at Parcel B, and included a point-by-point evaluation of the analytical history where groundwater concentrations exceeded the surface water quality criteria. Appendix I presents the details of this screening evaluation.

The surface water quality screening at Parcel B indicated that five metals (chromium VI, copper, lead, mercury, and nickel) in the A-aquifer consistently exceeded the screening criteria and, therefore, could affect the bay. No chemicals were identified to be of concern in the B-aquifer at Parcel B.

A trigger level was developed for each metal for each individual location where concentrations exceeded the screening criterion. The trigger level is a site-specific value that applies only to the location where it was derived to assess the potential future threat to the bay for each metal. The trigger level is based on the surface water quality criterion that is protective of the bay, but includes an attenuation factor that conservatively accounts for dispersion of the dissolved metal as it moves through the A-aquifer toward the bay. The trigger levels are concentrations greater than the surface water quality criteria, but low enough at the specific plume location that the metal concentration would be less than the surface water quality criterion after the metal moved through the aquifer and discharged to the bay. A comparison of the location-specific trigger levels with the concentrations of the metals at the sources was used to assess the degree of potential future threat to the bay and to identify whether additional studies or remedial actions would be needed. Appendix I presents a detailed description of the trigger level development and is summarized below.

3.3.4.1 Development of Trigger Levels for Groundwater

Appropriate surface water criteria for the protection of the bay were selected based on established surface water quality criteria. Formulation of selection criteria involved reference to chronic criteria if available, or acute criteria adjusted for chronic conditions if no chronic criteria were available. The lowest level of the two criteria that applied to the same exposure scenario was selected.

No water quality criteria for the protection of aquatic organisms exist for groundwater; therefore, alternative water quality criteria for groundwater must be developed to evaluate the potential for chemicals in groundwater at HPS to affect the bay. Direct application of the surface water quality criteria to groundwater to protect aquatic organisms from groundwater discharging to a surface water body is not appropriate, however. Chemical concentrations in groundwater tend to attenuate as the groundwater migrates toward its discharge point and as it mixes with surface water at the discharge point. For HPS, three discrete zones exist along the groundwater migration pathway: (1) the zone of groundwater transport from the source area to the tidal mixing zone, (2) the tidal mixing zone, and (3) the zone of groundwater discharge to the surface water body. Attenuation in the zone of groundwater transport occurs because of hydrodynamic dispersion, sorption, and biological and chemical transformations. Attenuation in the tidal mixing zone occurs because of those processes, and also because of dilution from surface water mixing with groundwater when high tides move bay water inland into the aquifer. Attenuation in the groundwater discharge zone occurs primarily because of dilution with the much larger volume of water present in the surface water body.

Location-specific trigger levels were developed by multiplying the appropriate attenuation factor calculated for the groundwater transport zone times the surface water quality criterion for the chemicals that potentially threaten the bay. Trigger levels were developed for chromium VI, copper, lead, mercury, and nickel derived from transport modeling, the surface water quality criteria, and the HGAL. These trigger levels reflect the following conservative assumptions:

1. The groundwater modeling for the transport zone assumed no sorption or biological or chemical transformation reactions and relied exclusively on hydrodynamic dispersion for attenuation of chemical concentrations.

2. The attenuation factor did not include attenuation in the tidal mixing zone or attenuation on discharge into the bay and instead included only attenuation in the groundwater transport zone.

3. The surface water quality criterion selected for some metals was derived from the chronic exposure scenario, even though the attenuation factor model assumed that groundwater did not mix with the bay water. Under a no-mixing scenario, the appropriate water quality criterion would be the acute scenario, which typically is a higher value.

The Navy used highly conservative measures throughout the surface water quality evaluation, as agreed to with the regulatory agencies. The table below summarizes the derived attenuation factors and the trigger levels proposed for specific well locations for the chemicals identified as potential threats to the bay.

Well, COC	Attenuation Factor	HGAL (µg/L)	Surface Water Quality Criterion (µg/L)	Proposed Trigger Level at Source Well (µg/L)	Conc. at Source Well (µg/L)[a]	Date of Sample	Source Well Conc. Exceeds Proposed Trigger Level?
IR07MW20A2, copper	1	28.04	3.1	28.04	40.6	Jul-91	YES
IR07MWS-1, nickel	4	96.48	8.2	386	322	Dec-91	NO
IR07MWS-2, lead	1	14.44	8.1	14.44	114	Sep-04	YES
IR10MW12A, chromium VI	4.5	NA	50	225	550	Mar-04	YES
IR20MW01A, mercury	4	0.6	0.025	2.4	2	Jan-94	NO
IR26MW47A, mercury	1	0.6	0.025	0.6	2.8	Nov-04	YES
IR26MW48A, lead	1	14.44	8.1	14.44	71.5	Sep-04	YES
PA50MW02A, mercury	1	0.6	0.025	0.6	0.91	Aug-94	YES

Note: a = Data set includes samples collected through November 2004.

3.3.4.2 *Use of Trigger Levels for Groundwater*

Inclusion of the six wells listed above in the groundwater monitoring program to be developed during the RD will be based on the concentrations observed in groundwater at these wells when the design is prepared. The groundwater data used for some of these wells were collected many years ago and may no longer represent current conditions in groundwater. For example, the concentration of copper at well IR07MW20A2 that exceeded the trigger level was measured in a sample collected in 1991, and this well has not been sampled since that time. Evaluations in the RD will consider current data for the six wells listed above and will not be limited to the data set ending in November 2004 that was used for the trigger level analysis. These newer data collected since November 2004 may indicate that monitoring is no longer necessary (for example, if the data show concentrations are consistently below the trigger level). Wells that were installed after the cut-off date for the surface water quality evaluation (November 2004) will also be included in the assessment during the RD. These evaluations will be described in the RD for review by the regulatory agencies.

The following additional evaluations may occur for the cases where current data indicate concentrations consistently exceed a trigger level:

- Increasing the frequency of monitoring in the well where the trigger level was exceeded to evaluate whether the elevated level is persistent;
- Monitoring groundwater at a location farther downgradient to evaluate whether the attenuation estimated in establishing the trigger level has occurred;
- Using site-specific detailed information to more accurately estimate attenuation (including processes such as adsorption and degradation); or
- Implementing a selected remediation alternative for groundwater treatment.

Trigger levels apply only to specific locations and chemicals; the point of measurement for comparison to a trigger level will be an individual groundwater monitoring well. In some cases, the point of measurement may be a well near the shoreline. For COCs present in groundwater near the shoreline, the chemical concentrations in groundwater at the point of measurement will be used to represent the concentrations that exist farther bayward at the interface of the sediment and the surface water of the bay where groundwater discharges (the point of exposure).

3.4 UPDATED RISK EVALUATION BY REDEVELOPMENT BLOCK

The following sections summarize the results of the incremental risk evaluation by redevelopment block. A list of sampling locations above remediation goals was compiled to identify locations at Parcel B where remedial action is required based on planned reuse. Tables 3-21 and 3-22 show the soil sampling locations where concentrations of COCs were measured above remediation goals for surface and subsurface soil. These soil sampling locations are identified on Figures 3-11 through 3-25 in the following sections. Groundwater plumes where concentrations were measured above remediation goals or trigger levels are discussed in the redevelopment block where they occur; the locations of groundwater monitoring wells are shown on the figures. Likewise, sediment sampling locations used in the SLERA to identify COCs that pose ecological risk are included in the discussions for the redevelopment block.

3.4.1 Redevelopment Block 1

Redevelopment Block 1 is located in the southern portion of IR-18 in the southwestern corner of Parcel B. Past activities at IR-18 that may have been sources for contamination include disposal of waste oil and placement of construction debris as fill. A portion of IR-18 was paved and was formerly used as a parking lot; there are no buildings on this block. Remedial action excavations removed soil from Redevelopment Block 1. The discovery of a small group of empty paint cans during excavation led to additional soil removals on the steep hillside in the southern part of Redevelopment Block 1. Based on the presence of debris fill, the Navy conducted a soil gas survey at IR-18 that included Redevelopment Block 1 (SES-TECH 2005). No methane or other VOCs were detected at this block during the survey.

Redevelopment Block 1 is identified for mixed use and was evaluated using a residential exposure scenario in the HHRA. Figure 3-11 presents the results of the incremental risk evaluation for soil at Redevelopment Block 1 and shows the locations of soil samples that were used in the HHRA. Highlighted sample point identification numbers (red font) indicate locations where the concentrations of one or more COCs exceeded remediation goals. The HHRA did not evaluate groundwater at Redevelopment Block 1 because no groundwater monitoring wells are located at this block. Previous investigations at Redevelopment Block 1 found no cause for installation of groundwater monitoring wells.

3.4.2 Redevelopment Block 2

Redevelopment Block 2 includes most of IR-18 and the southern portion of IR-07 in the western area of Parcel B. Past activities at IR-18 that may have been sources for contamination include disposal of waste oil and placement of construction debris as fill. A portion of IR-18 was paved and was formerly used as a parking lot. Past activities at IR-07 that may have contributed to soil contamination include painting submarine superstructures, disposal of sandblast waste, disposal of additional waste oils, and placement of construction debris as fill. There are no buildings on this block. Remedial action excavations removed soil from Redevelopment Block 2. Based on the presence of debris fill, the Navy conducted a soil gas survey at IR-07 and IR-18 that included Redevelopment Block 2 (SES-TECH 2005). No methane or other VOCs were detected at this block during the survey.

Redevelopment Block 2 is identified for research and development use and was evaluated using a residential exposure scenario in the HHRA. Figure 3-12 presents the results of the incremental risk evaluation for soil at Redevelopment Block 2 and shows the locations of soil samples that were used in the HHRA. Highlighted sample identification numbers indicate locations where the concentrations of one or more COCs exceeded remediation goals. The HHRA did not find any groundwater beneath Redevelopment Block 2 that contained concentrations that exceeded remediation goals. The HHRA identified potential risk at Redevelopment Block 2 (grid B0238) related to domestic use of groundwater in the B-aquifer based on results for samples collected from well IR18MW100B (see Figure 3-9). The risk at this grid resulted from a single detection of arsenic at 6.3 μg/L in a sample collected in July 1998. No detections of arsenic were observed in four subsequent samples collected from well IR18MW100B in October 1998 through October 2000, and the well was not sampled again after that. The observed concentration of arsenic, however, is less than the remediation goal (which is the HGAL of 27.3 μg/L). The western portion of Redevelopment Block 2 is one of the few locations at Parcel B where the B-aquifer is present and groundwater samples have been collected. The surface water quality screening evaluation did not identify any chemicals in groundwater that consistently exceeded the screening criteria.

3.4.3 Redevelopment Block 3

Redevelopment Block 3 includes part of IR-07 in the western area of Parcel B. Past activities at IR-07 that may have been sources for contamination include painting submarine superstructures, disposal of sandblast waste, disposal of additional waste oils, and placement of construction debris as fill. There are no buildings on this block. Remedial action excavations removed soil from Redevelopment Block 3. Based on the presence of debris fill, the Navy conducted a soil gas survey at IR-07 that included Redevelopment Block 3 (SES-TECH 2005). Methane and other VOCs were detected over an area of about 8,850 square feet at this block during the survey. Methane concentrations within this area ranged up to 17 percent. Other VOCs detected in samples collected from the area included benzene, toluene, ethylbenzene, xylene, chloroethane, vinyl chloride, and cis-1,2-dichloroethene. Concentrations of these VOCs ranged from 1.4 μg/L (vinyl chloride) to 109 μg/L (xylene) (SES-TECH 2005). Methane concentrations above 5 percent by volume in air are potentially explosive. As a result, the area of methane detections (that is, the methane source area) is included in the development of RAOs and in the analysis of remedial actions to mitigate this potential risk to human health.

Redevelopment Block 3 is identified for research and development use and was evaluated using a residential exposure scenario in the HHRA. Figure 3-13 presents the results of the incremental risk evaluation for soil at Redevelopment Block 3 and shows the locations of soil samples that were used in the HHRA. Highlighted sample identification numbers indicate locations where the concentrations of one or more COCs exceeded remediation goals. The HHRA did not find any unacceptable risks related to groundwater beneath Redevelopment Block 3. The surface water quality screening evaluation did not identify any chemicals in groundwater that consistently exceeded the screening criteria.

3.4.4 Redevelopment Block 4

Redevelopment Block 4 includes an area in the south-central portion of Parcel B that is largely not covered by IR sites; a small portion of IR-62 extends into Redevelopment Block 4. Past activities at IR-62 involved primarily fuel-related chemicals; a transformer substation at the northeast corner of Building 115 may have also contained PCB-bearing oil. Redevelopment Block 4 includes Buildings 103 (submarine barracks), 104 (naval reserve armory), 117 (submarine barracks), and a small portion of 116 (submarine training school). No remedial actions occurred at Redevelopment Block 4, and no soil or groundwater samples were collected at this block.

Redevelopment Block 4 is identified for mixed use and was evaluated using a residential exposure scenario in the HHRA. Figure 3-14 shows the layout of Redevelopment Block 4, but no risk results are presented because no information indicated the need for investigation and, therefore, no data were collected.

3.4.5 Redevelopment Block 5

Redevelopment Block 5 includes parts of IR-23 and IR-62 in the west-central portion of Parcel B. Past activities at IR-23 that may have been sources for contamination include surface spills of petroleum. Past activities at IR-62 involved primarily storage of fuel-related chemicals; a transformer substation at the northeastern corner of Building 115 may have also contained PCB-bearing oil. Redevelopment Block 5 includes Buildings 115 (offices and training), 116 (submarine training school), former Building 118 (submarine bachelor officers quarters and mess hall) and former Building 119 (submarine barracks). Redevelopment Block 5 also included former Tanks S-135 and S-136. Former Tank S-135 was located northwest of Building 116; former Tank S-136 was located south of Lockwood Street and south of Buildings 121 and 146. Tanks S-135 and S-136 were closed by the Water Board in 2003 (Water Board 2003a, 2003b). Remedial action excavations removed soil from Redevelopment Block 5.

Redevelopment Block 5 is identified for research and development use and was evaluated using a residential exposure scenario in the HHRA. Figure 3-15 presents the results of the incremental risk evaluation for soil at Redevelopment Block 5 and shows the locations of soil samples that were used in the HHRA. Highlighted sample identification numbers indicate locations where the concentrations of one or more COCs exceeded remediation goals. The HHRA identified a potential unacceptable risk related to vapor intrusion from VOCs in groundwater in the A-aquifer at Redevelopment Block 5, grid B1528 (see Figure 3-8) based on results for samples from well IR07MWS-1. This risk is based on exposure to volatile COCs in groundwater via inhalation of vapors that migrate from the subsurface to indoor air. The cancer risk at this grid resulted from a single detection of tetrachloroethene of 1 μg/L, in a sample collected in June 1992. No detections of tetrachloroethene were observed in two previous samples collected from well IR07MWS-1 in January and July 1991, but the well was not sampled after June 1992. The surface water quality screening evaluation did not identify any chemicals in groundwater that consistently exceeded the screening criteria.

3.4.6 Redevelopment Block 6

Redevelopment Block 6 includes part of IR-23 and IR-61 in the north-central portion of Parcel B. Past activities at IR-23 that may have been sources for contamination include surface spills of petroleum and use of photograph development chemicals at Building 146. Past activities at IR-61 that may have contributed to contamination in soil include release of PCB-containing oil from transformers. Redevelopment Block 6 includes Buildings 121 (civilian training center), 122 (electrical substation) and 146 (tactical air navigation facility). Remedial action excavations removed soil from Redevelopment Block 6.

Redevelopment Block 6 is identified for research and development use and was evaluated using a residential exposure scenario in the HHRA. Figure 3-16 presents the results of the incremental risk evaluation for soil at Redevelopment Block 6 and shows the locations of soil samples that were used in the HHRA. Highlighted sample identification numbers indicate locations where the concentrations of one or more COCs exceeded remediation goals. The HHRA did not find any unacceptable risks related to groundwater beneath Redevelopment Block 6. The surface water quality screening evaluation did not identify any chemicals in groundwater that consistently exceeded the screening criteria.

3.4.7 Redevelopment Block 7

Redevelopment Block 7 includes SI-31 and most of IR-42 in the south-central portion of Parcel B. Past activities at IR-42 that may have been sources for contamination include surface spills of petroleum chemicals associated with nondestructive testing, torpedo maintenance, and machine shop activities, and PCB-bearing oil associated with electrical transformers. No past activities at SI-31 are believed to have contributed to contamination in soil because SI-31 included only the site of offices at former Building 114. Redevelopment Block 7 includes Buildings 109 (police station), 113 (tug maintenance and salvage divers shops), 113A (machine shop, torpedo maintenance shop, tug maintenance shop, and electrical substation), and 120 (enlisted men's club) and former Building 114 (office building). Remedial action excavations removed soil from Redevelopment Block 7.

Redevelopment Block 7 is identified for mixed use and was evaluated using a residential exposure scenario in the HHRA. Figure 3-17 presents the results of the incremental risk evaluation for soil at Redevelopment Block 7 and shows the locations of soil samples that were used in the HHRA. Highlighted sample identification numbers indicate locations where the concentrations of one or more COCs exceeded remediation goals. The HHRA did not find any unacceptable risks related to groundwater beneath Redevelopment Block 7. The surface water quality screening evaluation did not identify any chemicals in groundwater that consistently exceeded the screening criteria.

3.4.8 Redevelopment Block 8

Redevelopment Block 8 includes IR-10 in the central portion of Parcel B. Past activities at IR-10 that may have been sources for contamination include releases of waste acids and plating solutions from floor drains inside Building 123, leaks from acid drain lines and an industrial drain line, and releases of PCB-bearing oil associated with transformers. The transformers are no longer in place at Building 123. Redevelopment Block 8 includes Building 123 (battery and electroplating shop). Remedial action excavations removed soil from Redevelopment Block 8. Treatability studies, including SVE and ZVI injection, have been and continue to be conducted at this Redevelopment Block 8 and have reduced chemical concentrations in soil and groundwater (see Section 2.1.4).

Redevelopment Block 8 is identified for mixed use and was evaluated using a residential exposure scenario in the HHRA. Figure 3-18 presents the results of the incremental risk evaluation for soil at Redevelopment Block 8 and shows the locations of soil samples that were used in the HHRA. Highlighted sample identification numbers indicate locations where the concentrations of one or more COCs exceeded remediation goals. The HHRA identified potential unacceptable risks related to vapor intrusion from VOCs in groundwater in the A-aquifer beneath Redevelopment Block 8—mostly related to the IR10-A plume (see Figure 3-8). This risk is based on exposure to volatile COCs in groundwater via inhalation of vapors that migrate from the subsurface to indoor air. The IR-10B plume contains chromium VI and is present in the A-aquifer at well IR10MW12A, just outside and northwest of Building 123. The extent of chromium VI in groundwater was found to be limited only to well IR10MW12A (see Section 2.1.3.2). The two most recent samples collected from well IR10MW12A detected chromium VI at 240 μg/L (collected in March 2006) (CE2-Kleinfelder 2007a) and 487 μg/L (collected in May 2006) (CE2-Kleinfelder 2007b). The maximum concentration of chromium VI detected at well IR10MW12A was 680 μg/L (collected in December 2005). The maximum concentration of chromium VI in the HHRA data set was 550 μg/L (collected in March 2004). The HHRA did not find any unacceptable risks related to concentrations of chromium VI. Inclusion of the 680 μg/L concentration would not change the HHRA result. The HHRA also identified potential unacceptable risks related to vapor intrusion from VOCs in groundwater in the A-aquifer related to the IR-25 plume (see Figure 3-8). The IR-25 plume extends into Redevelopment Block 8 only based on a single detection of 1,2-dichloroethene in a sample collected from well IR10MW14A in 1994. However, this well is monitored quarterly under the RAMP and neither cis- nor trans-1,2-dichloroethene has been detected during the past 10 monitoring events. Most of the IR-25 plume is located within Redevelopment Block 12, and that plume is discussed in detail as part of Redevelopment Block 12.

The surface water quality screening evaluation indicated that chromium VI was a COC at Redevelopment Block 8. Chromium VI was detected in 5 of 12 samples collected from well IR10MW12A from March 2002 to November 2004 at concentrations that exceeded the trigger level of 225 μg/L. Chromium VI was included as a COC.

3.4.9 Redevelopment Block 9

Redevelopment Block 9 includes a large part of IR-24 in the north-central portion of Parcel B. Past activities at IR-24 that may have been sources for contamination include surface spills of petroleum and releases of diesel fuel and lubrication oils along distribution pipelines (IR-46) that ran through IR-24 and releases of oils, solvents, paints, and corrosives from Buildings 128 and 130. Redevelopment Block 9 includes Building 128 (machine shop) and parts of Building 125 (submarine cafeteria) and 130 (machine shop). Remedial action excavations removed soil from Redevelopment Block 9.

Redevelopment Block 9 is identified for mixed use and was evaluated using a residential exposure scenario in the HHRA. Figure 3-19 presents the results of the incremental risk evaluation for soil at Redevelopment Block 9 and shows the locations of soil samples that were used in the HHRA. Highlighted sample identification numbers indicate locations where the concentrations of one or more COCs exceeded remediation goals. The HHRA identified a potential unacceptable risk related to vapor intrusion from VOCs in groundwater in the A-aquifer at Redevelopment Block 9 related to the IR-10A plume, discussed above at adjacent Redevelopment Block 8 (see Figure 3-8 also). The surface water quality screening evaluation did not identify any chemicals in groundwater that consistently exceeded the screening criteria.

3.4.10 Redevelopment Block 12

Redevelopment Block 12 includes most of IR-20 and part of IR-24 in the northeastern portion of Parcel B. Past activities at IR-20 that may have contributed to contamination in soil include spills of waste oil and chemicals within and outside of Building 156. Past activities at IR-24 that may have been sources for contamination include surface spills of petroleum and releases of diesel fuel and lubrication oils along distribution pipelines (IR-46) that ran through IR-24 and releases of oils, solvents, and paints from Building 130. Redevelopment Block 12 includes Building 156 (rubber shop) and part of Building 130 (machine shop). Remedial action excavations removed soil from Redevelopment Block 12.

Redevelopment Block 12 is identified for mixed use and was evaluated using a residential exposure scenario in the HHRA. Figure 3-20 presents the results of the incremental risk evaluation for soil at Redevelopment Block 12 and shows the locations of soil samples that were used in the HHRA. Highlighted sample identification numbers indicate locations where the concentrations of one or more COCs exceeded remediation goals.

The HHRA identified a potential unacceptable risk related to vapor intrusion from VOCs in groundwater in the A-aquifer at Redevelopment Block 12—both related to the IR-25 plume and individual grid B4516 (well IR26MW41A). This risk is based on exposure to volatile COCs in groundwater via inhalation of vapors that migrate from the subsurface to indoor air. The IR-25 plume extends into Redevelopment Block 12 (see Figure 3-8), based on sporadic detections of trichloroethene and chloroform in samples collected from wells IR24MW04A, IR25MW61A1, and IR25MW61A2. The detection of trichloroethene at well IR24MW04A was 1.5 μg/L in a sample collected in 1995, and the well was not sampled again. Chloroform was detected in June 2004 in samples from well IR25MW61A1 (0.5 μg/L) and well IR25MW61A2 (0.59 μg/L); however, chloroform was not detected in the four most recent monitoring rounds (through May 2006). The Navy's recent investigation of VOCs along the boundary between Parcels B and C in this area did not obtain any additional information that would affect the IR-25 groundwater risk plume at Redevelopment Block 12.

The noncancer risk at grid B4516 results from nine detections of dichlorodifluoromethane, ranging from 18 to 59 μg/L in samples collected from well IR26MW41A from March 2003 to November 2004. Dichlorodifluoromethane was detected at 15 μg/L in a sample from well IR26MW41A collected during November 2006; dichlorodifluoromethane was not detected in the sample collected in March 2007. The surface water quality screening evaluation did not identify any chemicals in groundwater that consistently exceeded the screening criteria.

3.4.11 Redevelopment Block 15

Redevelopment Block 15 includes parts of IR-20 and IR-26 in the northeastern portion of Parcel B. Past activities at IR-20 that may have contributed to contamination in soil include spills of waste oil and chemicals at Building 156, which is located west of Redevelopment Block 15. Past activities at IR-26 that may have been sources for contamination include surface spills of petroleum welding and fabrication of metal parts, and sandblasting. Redevelopment Block 15 includes Building 157 (nondestructive testing laboratory). Remedial action excavations removed soil from Redevelopment Block 15.

Redevelopment Block 15 is identified for mixed use and was evaluated using a residential exposure scenario in the HHRA. Figure 3-21 presents the results of the incremental risk evaluation for soil at Redevelopment Block 15 and shows the locations of soil samples that were used in the HHRA. Highlighted sample identification numbers indicate locations where the concentrations of one or more COCs exceeded remediation goals. The HHRA did not find any unacceptable risks related to groundwater.

The surface water quality screening evaluation indicated that mercury was a COC at Redevelopment Block 15. Mercury was detected in two of four samples collected from well PA50MW02A from March 1993 to July 2001; two concentrations (0.91 μg/L in August 1994 and 0.65 μg/L in July 2001) exceeded the trigger level of 0.6 μg/L. Well PA50MW02A was not sampled after July 2001; mercury was included as a COC.

3.4.12 Redevelopment Block 16

Redevelopment Block 16 includes part of IR-26 in the eastern portion of Parcel B. Past activities at IR-26 that may have contributed to contamination in soil include surface spills of petroleum, releases of chemicals from the dock shipwright's shop, and sandblasting. Redevelopment Block 16 includes Building 140 (pump house for dry dock 3) and former Buildings 141 (dock shipwright's shop) and 142 (air raid shelter). Remedial action excavations removed soil from Redevelopment Block 16.

Redevelopment Block 16 is identified for educational/cultural use and was evaluated using an industrial exposure scenario in the HHRA. Figure 3-22 presents the results of the incremental risk evaluation for soil at Redevelopment Block 16 and shows the locations of soil samples that were used in the HHRA. Highlighted sample identification numbers indicate locations where the concentrations of one or more COCs exceeded remediation goals. The HHRA identified a potential unacceptable risk related to vapor intrusion from VOCs in groundwater in the A-aquifer at Redevelopment Block 16, grid AY04 (see Figure 3-8) based on results for samples from well IR26MW45A. This risk is based on exposure to volatile COCs in groundwater via inhalation of vapors that migrate from the subsurface to indoor air. The cancer risk at this grid results from three detections of chloroform, ranging from 3 μg/L to 4 μg/L in samples collected from September 1999 to January 2001. The well was decommissioned in February 2001 during remedial action excavation (Excavation EE-05).

The surface water quality screening evaluation indicated that lead was a COC at well IR26MW48A in Redevelopment Block 16. Lead was detected at 71.5 μg/L in a sample collected in September 2004; this concentration exceeded the trigger level of 14.44 μg/L. Nine previous samples dating to March 2002 did not indicate detections of lead; however, well IR26MW48A was not sampled after September 2004 so lead was conservatively included as a COC.

3.4.13 Redevelopment Block BOS-1

Redevelopment Block BOS-1 includes parts of IR-07, IR-18, and IR-23 in the western and northwestern portion of Parcel B. Past activities at IR-07 that may have contributed to contamination in soil include painting submarine superstructures, disposal of sandblast waste, disposal of additional waste oils, and placement of construction debris as fill. Past activities at IR-18 that may have been sources for contamination include disposal of waste oil and placement of construction debris as fill. Past activities at IR-23 that may have been sources for contamination include surface spills of petroleum and use of photograph development chemicals at Building 146. Waste oil that contained PCBs was also disposed of in the northern portion of Redevelopment Block BOS-1 (within grid AI08). The Navy removed PCB-contaminated soils to a maximum depth of 19 feet bgs at Excavation 7-5 to remove as much of the contaminated soil as possible during remedial actions. Redevelopment Block BOS-1 includes Building 144 (latrine) and Building 145 (saltwater pumphouse). Remedial action excavations removed soil from Redevelopment Block BOS-1.

Redevelopment Block BOS-1 is identified for open space and was evaluated using a recreational exposure scenario in the HHRA. Figure 3-23 presents the results of the incremental risk evaluation for soil at Redevelopment Block BOS-1 and shows the locations of soil samples that were used in the HHRA. Highlighted sample identification numbers indicate locations where the concentrations of one or more COCs exceeded remediation goals. Figure 3-23 also shows the area where soil samples were used for the SLERA. The SLERA identified potential unacceptable risks to ecological receptors related to sediments along the shoreline at Redevelopment Block BOS-1.

The HHRA identified potential risk at Redevelopment Block BOS-1 (grids B0139 and B0237) related to domestic use of groundwater in the B-aquifer based on results for samples collected from wells IR18MW21A and PA18MW09A (see Figure 3-9). The risk at these grids resulted from samples collected from the A-aquifer; however, the HHRA considered these data in the domestic use scenario for the B-aquifer based on potential hydraulic communication between the A- and B-aquifers in this portion of Parcel B. Five organic compounds from well IR18MW21A were identified to cause risk: benzene; chloroethane; 1,4-dichlorobenzene; pentachlorophenol; and trichloroethene. Except 1,4-dichlorobenzene, the risk resulted from a single detection and subsequent samples all found no detections. Three detections were observed for 1,4-dichlorobenzene ranging from 0.27 to 0.41 μg/L, but all were below the remediation goal. Four inorganic compounds from wells IR18MW21A and PA18MW09A were identified to cause risk: antimony, arsenic, manganese, and thallium. However, all detections of these four metals were lower than the remediation goals (which are the corresponding HGALs).

The surface water quality screening evaluation indicated that copper and lead were COCs at Redevelopment Block BOS-1. Copper was detected at 40.6 µg/L in a sample collected in July 1991 and at 30.25 µg/L in a sample collected in June 1992 at well IR07MW20A2; these concentrations exceeded the trigger level of 28.04 µg/L. Well IR07MW20A2 was not sampled after June 1992, and copper was included as a COC. Lead was detected at 114 µg/L in a sample collected in September 2004 at well IR07MWS-2; this concentration exceeded the trigger level of 14.44 µg/L. Ten previous samples dating to March 2002 did not indicate detections of lead; however, well IR07MWS-2 was not sampled after September 2004, so lead was conservatively included as a COC.

3.4.14 Redevelopment Block BOS-2

Redevelopment Block BOS-2 includes IR-60 and parts of IR-23 and IR-24 in the north-central portion of Parcel B. Past activities at IR-60 that may have contributed to contamination in soil include releases of chemicals related to ship painting activities and associated waste disposal. Past activities at IR-23 that may have been sources for contamination include surface spills of petroleum and use of photograph development chemicals at Building 146. Past activities at IR-24 that may have been sources for contamination include surface spills of petroleum, releases of diesel fuel and lubrication oils along distribution pipelines (IR-46) that ran through IR-24, and releases of oils, solvents, paints, and corrosives from Building 128. Decontamination of ships from Operation Crossroads at Dry Docks 5, 6, and 7 may also have affected this redevelopment block (Radiological Affairs Support Office 2004). Redevelopment Block BOS-2 includes Buildings 133 and 159 (both latrines) and a small portion of Building 128. Remedial action and total petroleum hydrocarbon removal excavations removed soil from Redevelopment Block BOS-2.

Redevelopment Block BOS-2 is identified for open space and was evaluated using a recreational exposure scenario in the HHRA. Figure 3-24 presents the results of the incremental risk evaluation for soil at Redevelopment Block BOS-2 and shows the locations of soil samples that were used in the HHRA. Highlighted sample identification numbers indicate locations where the concentrations of one or more COCs exceeded remediation goals. A seawall forms the shoreline at Redevelopment Block BOS-2 and there is no exposed sediment; therefore, the SLERA did not evaluate risks to ecological receptors related to sediments along the shoreline at Redevelopment Block BOS-2. The HHRA did not find any unacceptable risks related to groundwater. The surface water quality screening evaluation did not identify any chemicals in groundwater that consistently exceeded the screening criteria.

3.4.15 Redevelopment Block BOS-3

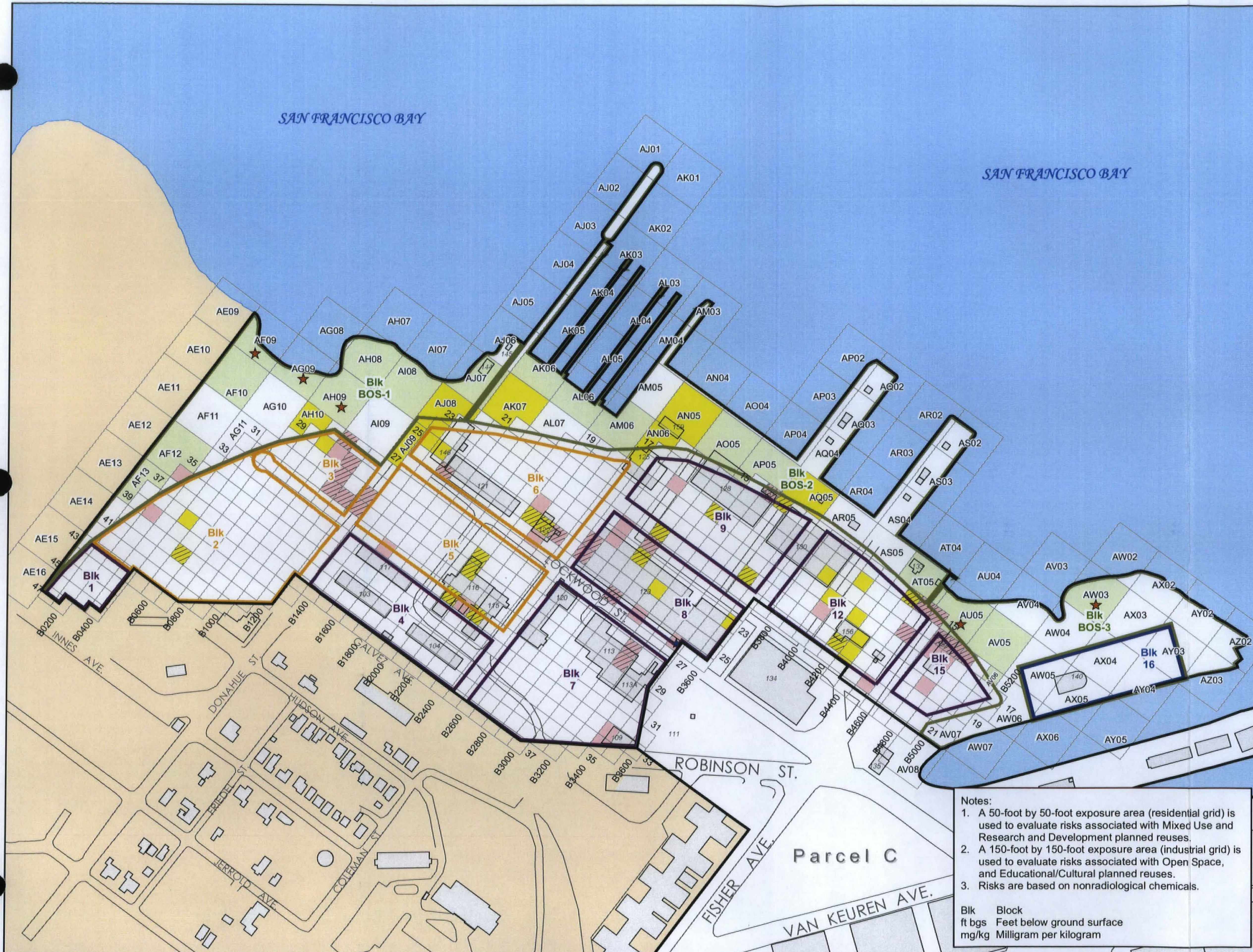
Redevelopment Block BOS-3 includes most of IR-26 in the eastern portion of Parcel B. Past activities at IR-26 that may have contributed to contamination in soil include surface spills of petroleum and releases of chemicals from the dock shipwright's shop in adjacent Redevelopment Block 16. Decontamination of ships from Operation Crossroads at Dry Dock 3 may also have affected this redevelopment block (Radiological Affairs Support Office 2004). There are no buildings on this block. Remedial action excavations removed soil from Redevelopment Block BOS-3.

Redevelopment Block BOS-3 is identified for open space and was evaluated using a recreational exposure scenario in the HHRA. Figure 3-25 presents the results of the incremental risk evaluation for soil at Redevelopment Block BOS-3 and shows the locations of soil samples that were used in the HHRA. Highlighted sample identification numbers indicate locations where the concentrations of one or more COCs exceeded remediation goals. Figure 3-25 also shows the area where soil samples were used for the SLERA. The SLERA identified potential unacceptable risks to ecological receptors related to sediments along the shoreline at Redevelopment Block BOS-3.

The HHRA did not find any unacceptable risks related to groundwater. The SLERA, however, identified potential unacceptable risks to ecological receptors related to mercury in groundwater at Redevelopment Block BOS-3 based on comparison to surface water screening criteria. Mercury was detected consistently in groundwater samples collected from well IR26MW47A (grid AY02) at concentrations ranging from 0.18 μg/L to 2.8 μg/L from March 2002 when the well was installed through November 2004. However, mercury was not detected in samples from nearby wells IR26MW46A and IR26MW48A during the same time period. The Navy installed two additional groundwater monitoring wells (IR26MW49A and IR26MW50A) at Redevelopment Block BOS-3 in July 2006. Concentrations of mercury in samples collected from well IR26MW49A ranged from 0.88 μg/L in November 2006 to 0.96 μg/L in March 2007. Mercury was not detected in samples collected from well IR26MW50A in November 2006 and March 2007. Figure 3-25 shows the locations of these five groundwater monitoring wells.

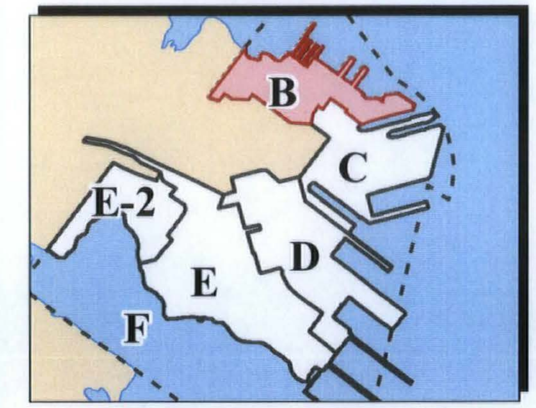
The surface water quality screening evaluation indicated that mercury was a COC at Redevelopment Block BOS-3. Mercury was detected in 10 of 12 samples collected from well IR26MW47A from March 2002 to November 2004 at concentrations that exceeded the trigger level of 0.6 μg/L. Mercury was included as a COC.

FIGURES



Notes:
1. A 50-foot by 50-foot exposure area (residential grid) is used to evaluate risks associated with Mixed Use and Research and Development planned reuses.
2. A 150-foot by 150-foot exposure area (industrial grid) is used to evaluate risks associated with Open Space, and Educational/Cultural planned reuses.
3. Risks are based on nonradiological chemicals.

Blk Block
ft bgs Feet below ground surface
mg/kg Milligram per kilogram



Location Map

- Recreational Lead Concentration > 155 mg/kg
- Residential Lead Concentration > 155 mg/kg
- Parcel Boundary
- Research and Development
- Mixed Use
- Open Space
- Educational/Cultural
- Highest Segregated Hazard Index >1
- No Data
- Residential Cancer Risk > 1E-06
- Recreational Cancer Risk > 1E-06
- Residential and Recreational Cancer Risk ≤ 1E-06
- Road
- 128 Building
- San Francisco Bay
- Non-Navy Property

0 300 600
Scale in Feet

ChaduxTt JV
Consulting Engineers and Scientists

Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-2
TOTAL RISK - SURFACE SOIL (0 TO 2 FT BGS) BASED ON PLANNED REUSE
TMSRA for Parcel B

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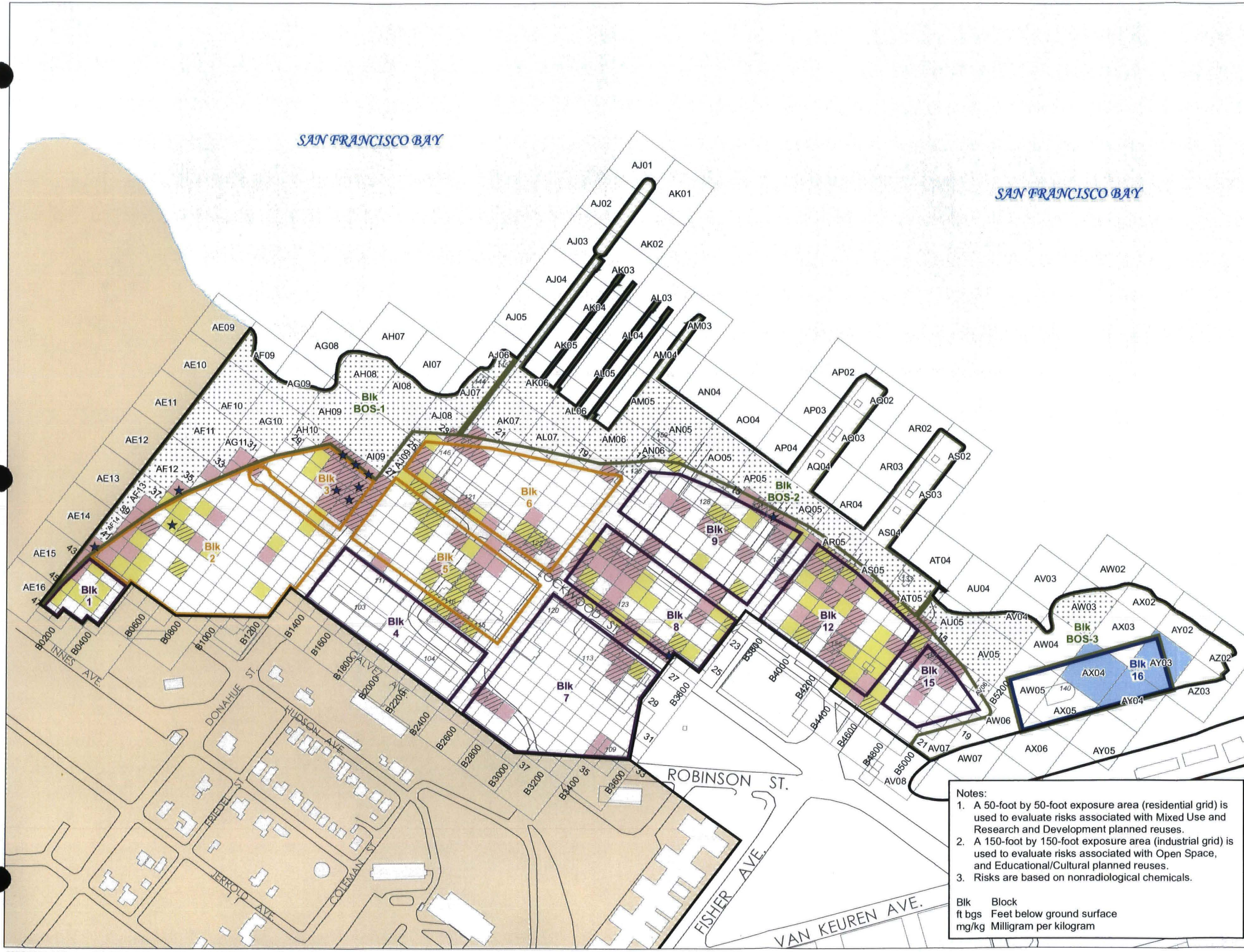

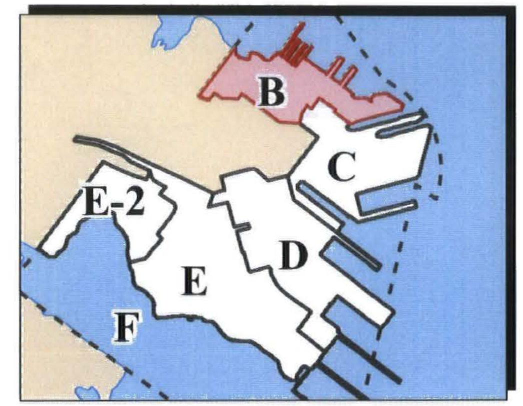

Location Map

★ Residential Lead Concentration > 155 mg/kg
Industrial Cancer Risk > 1E-06
Residential Cancer Risk > 1E-06
Residential Cancer Risk ≤ 1E-06
Highest Segregated Hazard Index > 1
Data Available; Recreational Scenario Not Evaluated for Subsurface Soil
No Data
Parcel Boundary
Research and Development
Mixed Use
Open Space
Educational/Cultural
Road
128 Building
Non-Navy Property
San Francisco Bay

N

0 300 600

Scale in Feet

Notes:

1. A 50-foot by 50-foot exposure area (residential grid) is used to evaluate risks associated with Mixed Use and Research and Development planned reuses.
2. A 150-foot by 150-foot exposure area (industrial grid) is used to evaluate risks associated with Open Space, and Educational/Cultural planned reuses.
3. Risks are based on nonradiological chemicals.

Blk Block
ft bgs Feet below ground surface
mg/kg Milligram per kilogram

ChaduxTt JV

Consulting Engineers and Scientists

Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-3

TOTAL RISK - SUBSURFACE SOIL (0 TO 10 FT BGS) BASED ON PLANNED REUSE

TMSRA for Parcel B

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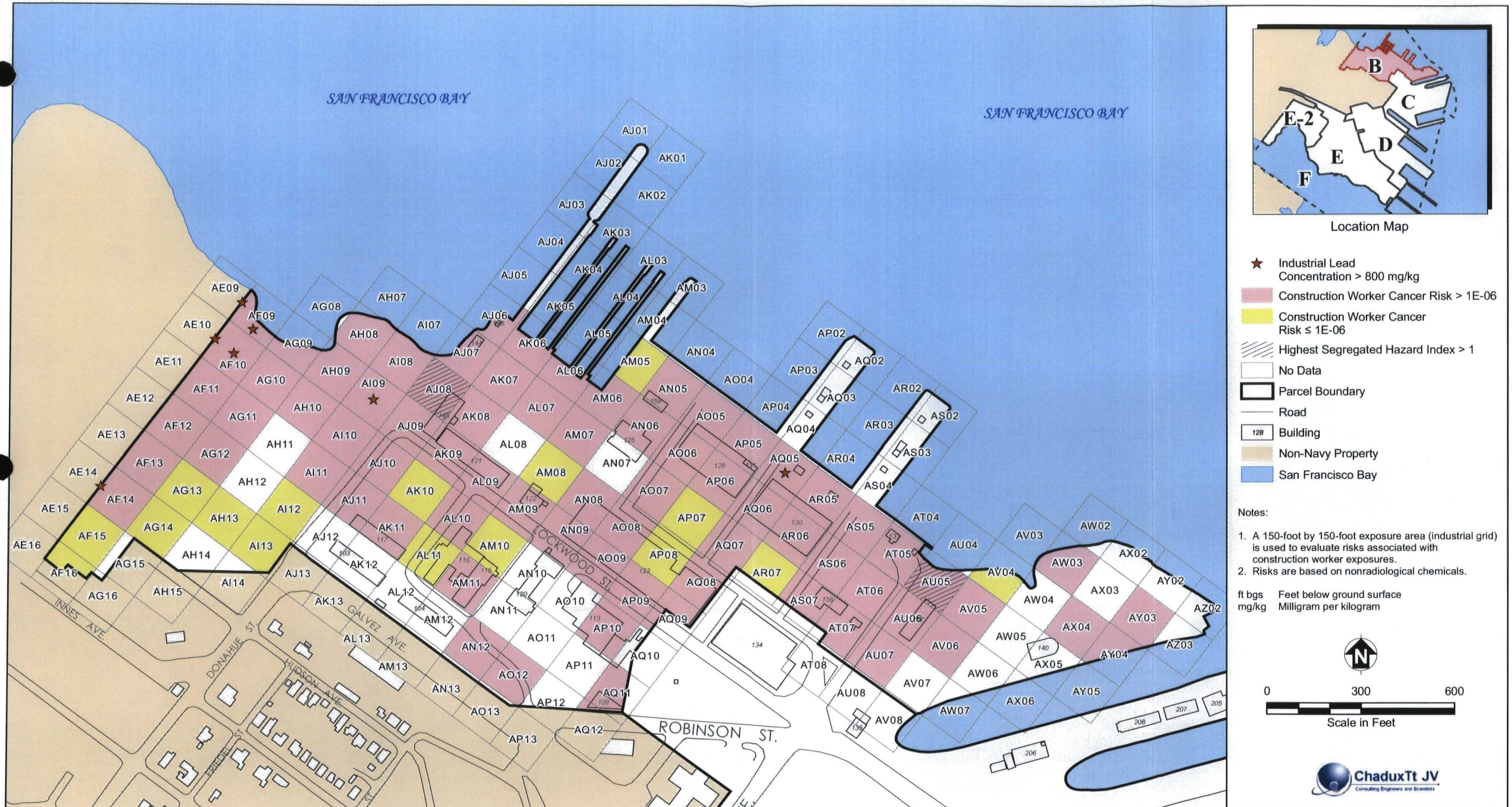

Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-4
TOTAL RISK - SUBSURFACE SOIL (0 TO 10 FT BGS), CONSTRUCTION WORKER EXPOSURE SCENARIO

TMSRA for Parcel B

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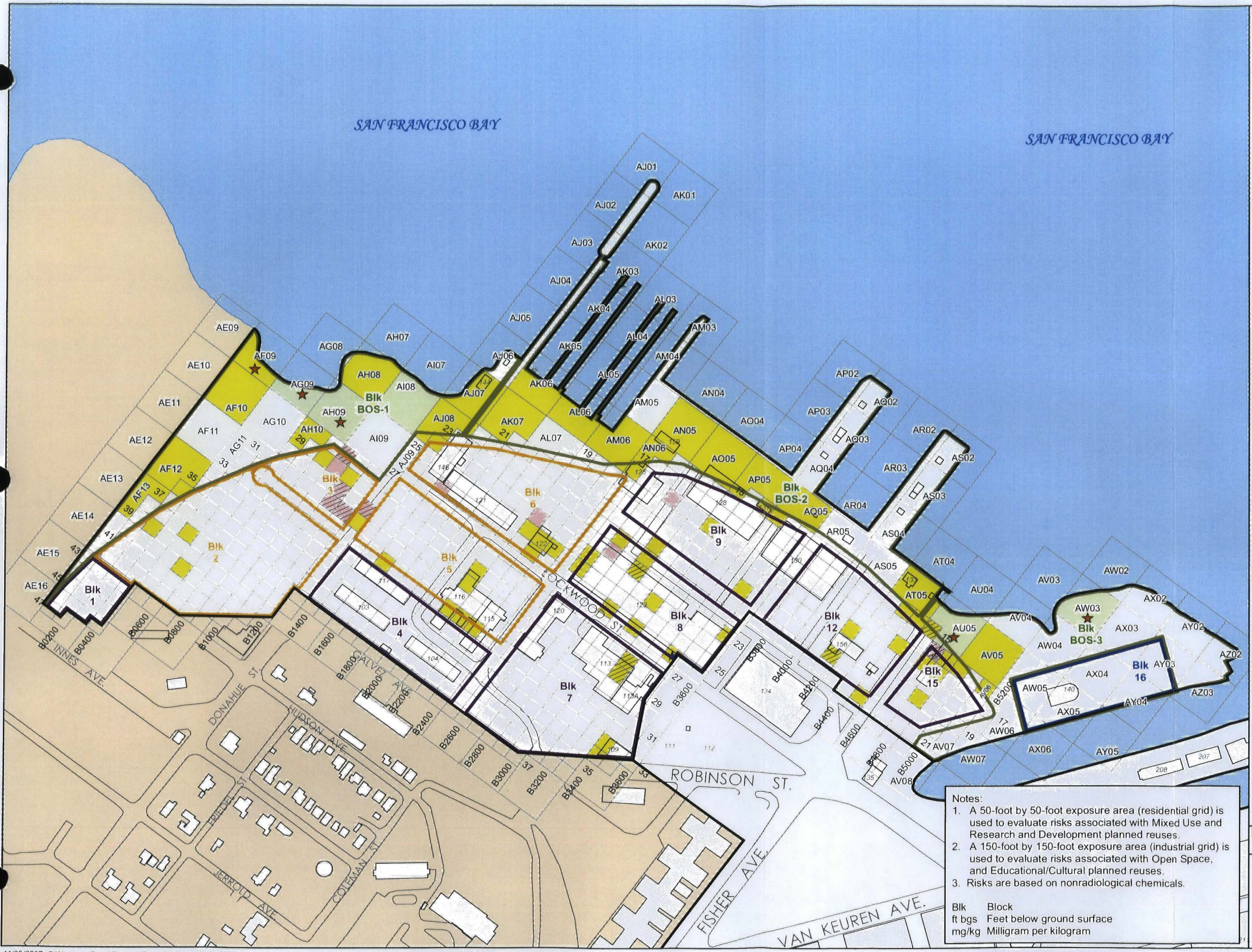

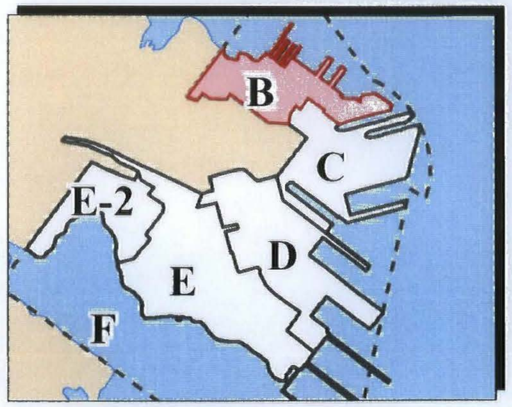

Location Map

- ★ Residential Lead Concentration > 155 mg/kg
- ★ Recreational Lead Concentration > 155 mg/kg
- Road
- Residential Cancer Risk > 1E-06
- Recreational Cancer Risk > 1E-06
- Residential and Recreational Cancer Risk ≤ 1E-06
- Highest Segregated Hazard Index > 1
- No Data
- Parcel Boundary
- Research and Development
- Mixed Use
- Open Space
- Educational/Cultural
- 128 Building
- Non-Navy Property
- San Francisco Bay

N

0 300 600

Scale in Feet

Notes:

1. A 50-foot by 50-foot exposure area (residential grid) is used to evaluate risks associated with Mixed Use and Research and Development planned reuses.
2. A 150-foot by 150-foot exposure area (industrial grid) is used to evaluate risks associated with Open Space, and Educational/Cultural planned reuses.
3. Risks are based on nonradiological chemicals.

Blk Block
ft bgs Feet below ground surface
mg/kg Milligram per kilogram

ChaduxTt JV

Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-5
INCREMENTAL RISK - SURFACE SOIL
(0 TO 2 FT BGS)
BASED ON PLANNED REUSE

TMSRA for Parcel B

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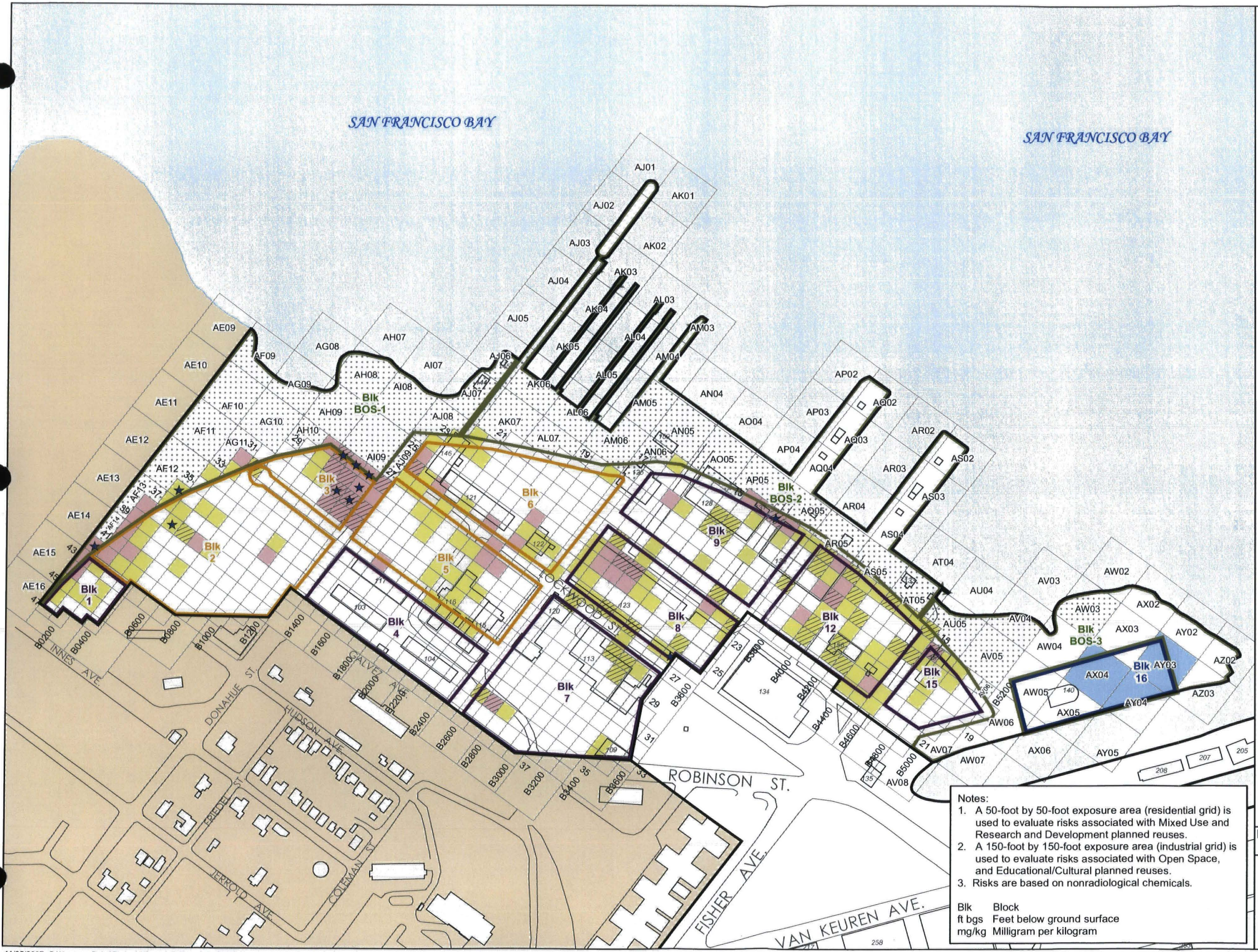

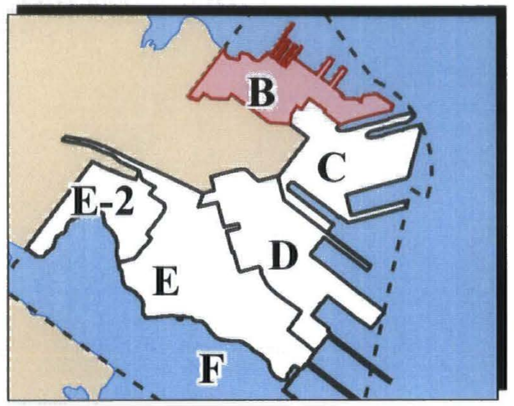

Location Map

★ Residential Lead Concentration > 155 mg/kg
Industrial Cancer Risk > 1E-06
Residential Cancer Risk > 1E-06
Residential Cancer Risk ≤ 1E-06
Highest Segregated Hazard Index > 1
Data Available; Recreational Scenario Not Evaluated for Subsurface Soil
No Data
Parcel Boundary
Research and Development
Mixed Use
Open Space
Educational/Cultural
Road
Building
Non-Navy Property
San Francisco Bay

0 300 600
Scale in Feet

ChaduxTt JV

Notes:
1. A 50-foot by 50-foot exposure area (residential grid) is used to evaluate risks associated with Mixed Use and Research and Development planned reuses.
2. A 150-foot by 150-foot exposure area (industrial grid) is used to evaluate risks associated with Open Space, and Educational/Cultural planned reuses.
3. Risks are based on nonradiological chemicals.

Blk Block
ft bgs Feet below ground surface
mg/kg Milligram per kilogram

Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-6
INCREMENTAL RISK - SUBSURFACE SOIL (0 TO 10 FT BGS) BASED ON PLANNED REUSE
TMSRA for Parcel B

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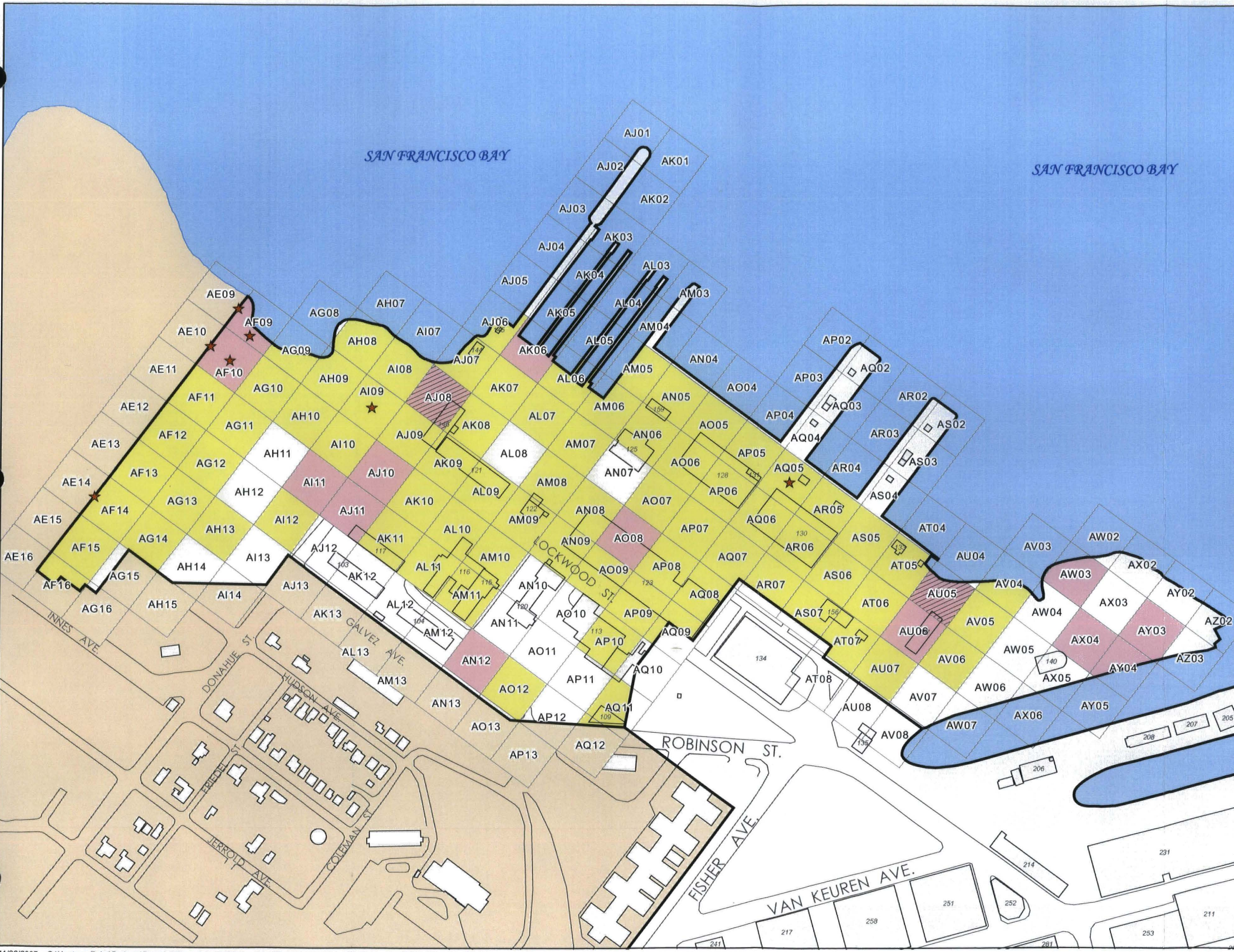
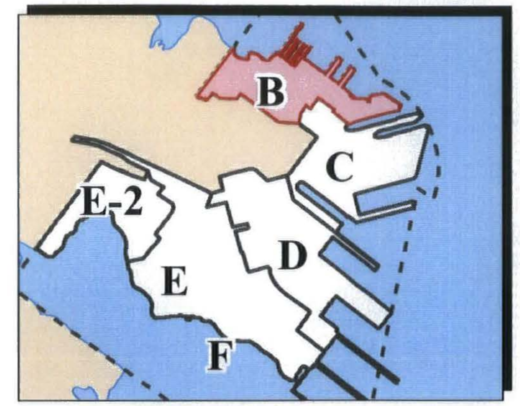




Location Map

★ Industrial Lead Concentration > 800 mg/kg

Construction Worker Cancer Risk > 1E-06

Construction Worker Cancer Risk ≤ 1E-06

Highest Segregated Hazard Index > 1

No Data

Parcel Boundary

Road

128 Building

Non-Navy Property

San Francisco Bay

Notes:

1. A 150-foot by 150-foot exposure area (industrial grid) is used to evaluate risks associated with construction worker exposures.
2. Risks are based on nonradiological chemicals.

ft bgs Feet below ground surface
mg/kg Milligram per kilogram

0 300 600

Scale in Feet

ChaduxTt JV

Hunters Point Shipyard, San Francisco, California

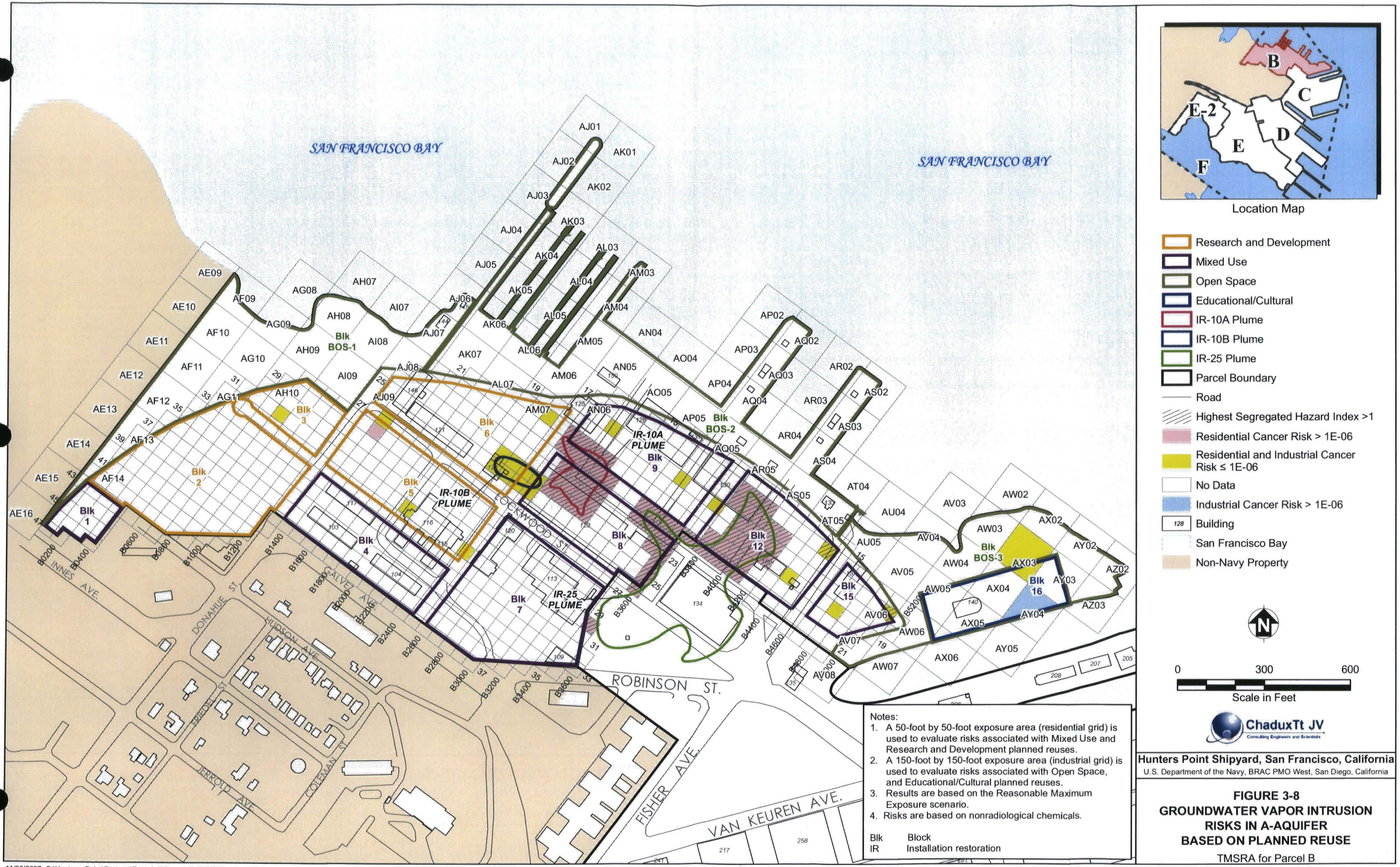
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-7

INCREMENTAL RISK - SUBSURFACE SOIL (0 TO 10 FT BGS), CONSTRUCTION WORKER EXPOSURE SCENARIO

TMSRA for Parcel B

11/06/2007 O:\Hunters_Point\Projects\Parcel_B\Parcel_B_TMSRA\projects\Fig3-07_IR010ConstWorker.mxd TtEMI-DN Kurt.Cholak



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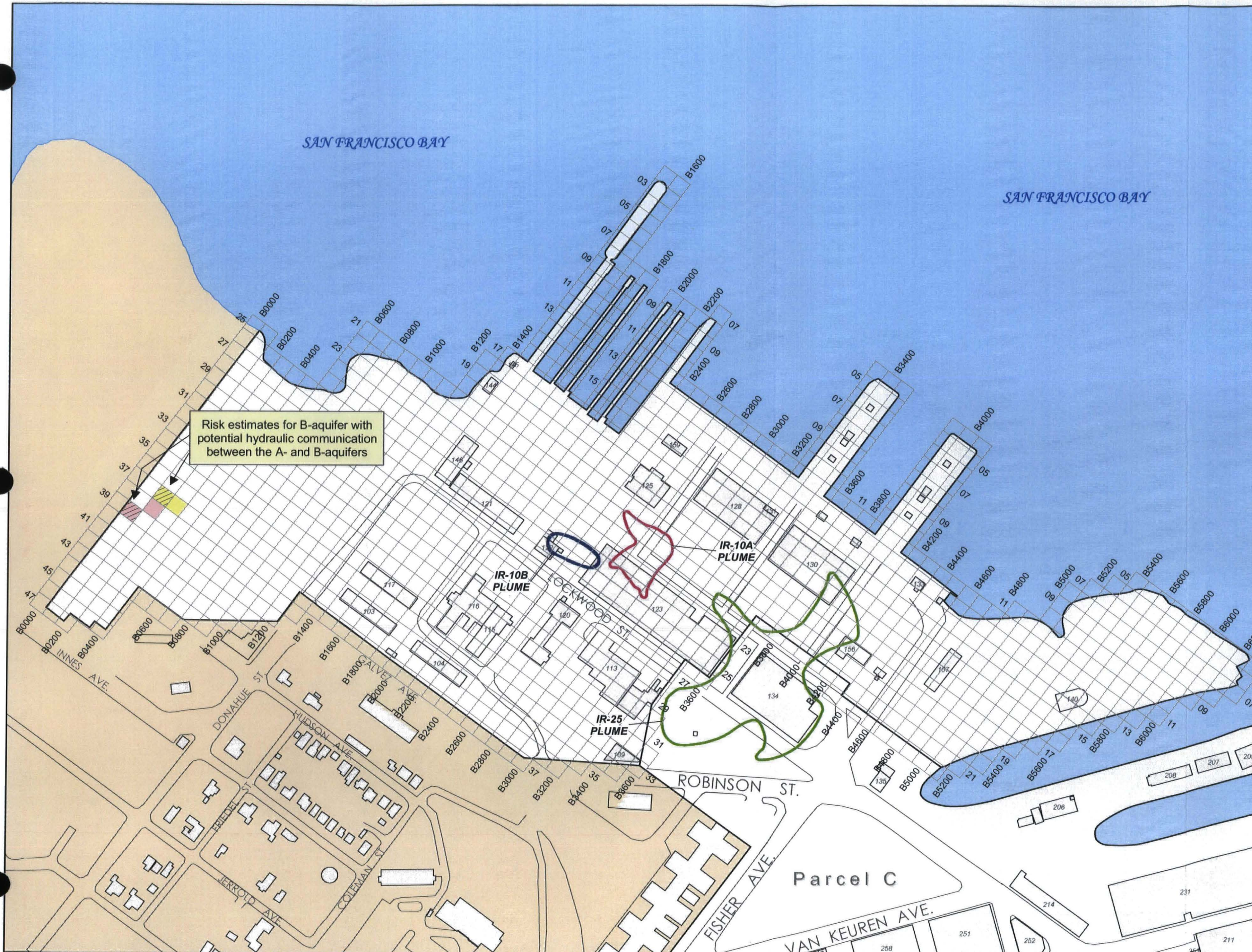

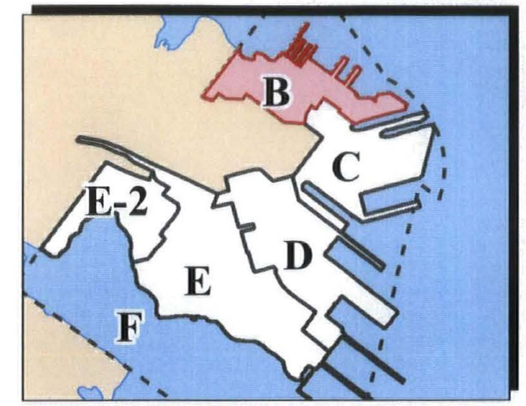

Location Map

- IR-10A Plume
- IR-10B Plume
- IR-25 Plume
- Parcel Boundary
- Highest Segregated Hazard Index > 1
- Residential Cancer Risk > 1E-06
- Residential Cancer Risk ≤ 1E-06
- Road
- 128 Building
- San Francisco Bay
- Non-Navy Property

Notes:

1. Results are based on the reasonable maximum exposure scenario.
2. A 50-foot by 50-foot exposure area (residential grid) is used to evaluate risks associated with residential exposures.
3. Risks are based on nonradiological chemicals.

IR Installation Restoration

N

0 300 600

Scale in Feet

ChaduxTt JV

Consulting Engineers and Scientists

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U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-9
GROUNDWATER DOMESTIC USE RISKS IN B-AQUIFER, RESIDENTIAL EXPOSURE SCENARIO

TMSRA for Parcel B

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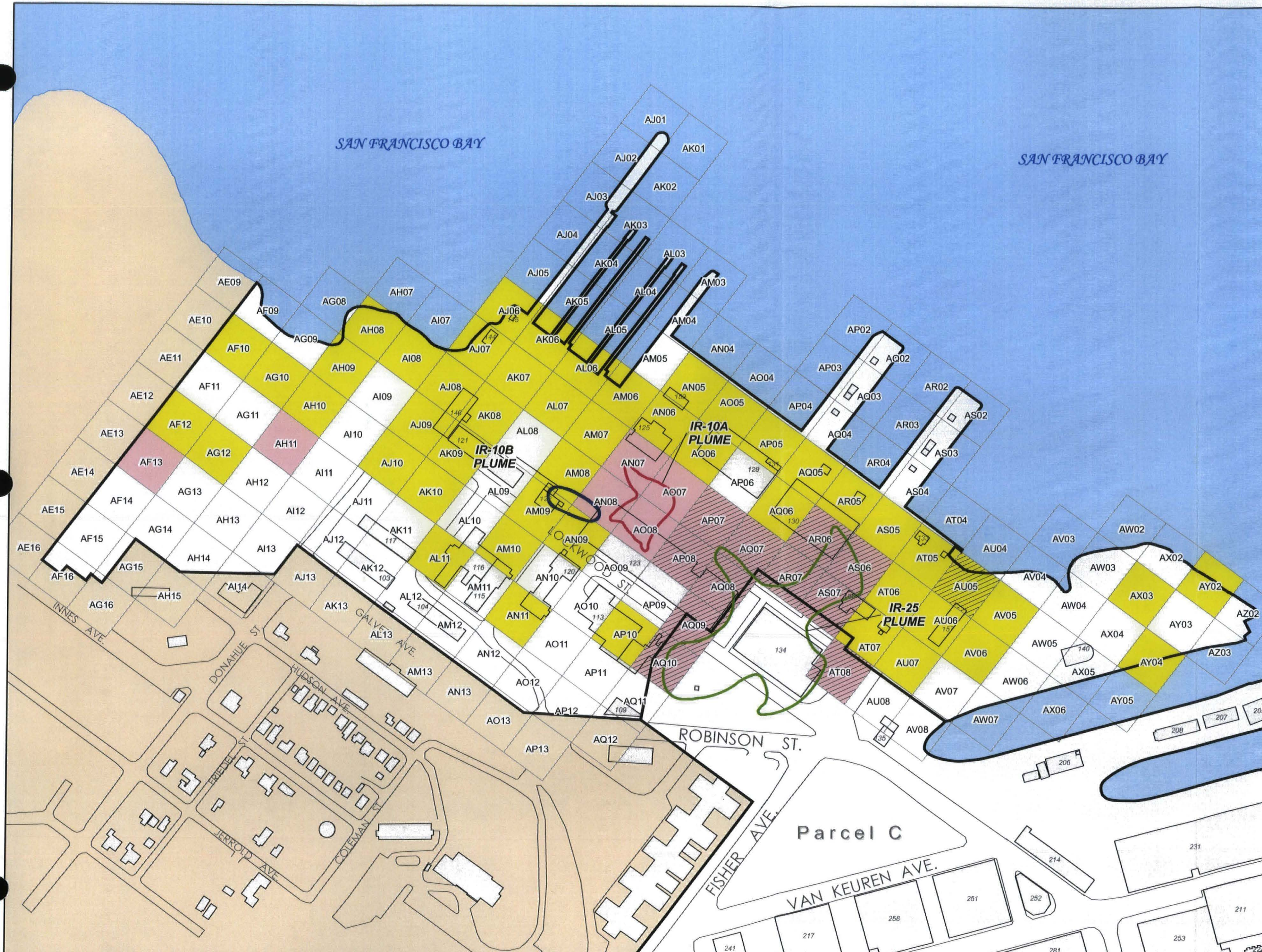

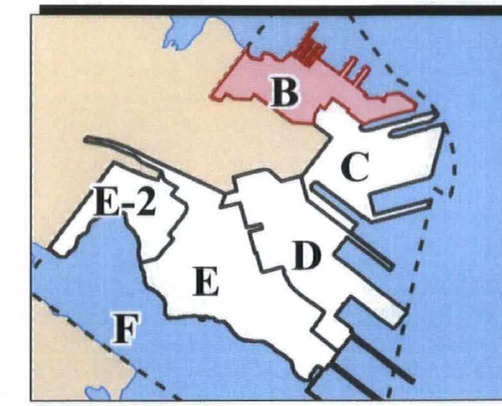

Location Map

- IR-10A Plume
- IR-10B Plume
- IR-25 Plume
- Parcel Boundary
- No Data
- Highest Segregated Hazard Index > 1
- Construction Worker Cancer Risk > 1E-06
- Construction Worker Cancer Risk ≤ 1E-06
- Road
- 128 Building
- San Francisco Bay
- Non-Navy Property

Notes:
1. Results are based on the reasonable maximum exposure scenario.
2. A 150-foot by 150-foot exposure area (industrial grid) is used to evaluate risks associated with industrial exposures.
3. Risks are based on nonradiological chemicals.

IR Installation Restoration

N

0 300 600

Scale in Feet

ChaduxTt JV

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FIGURE 3-10
TRENCH GROUNDWATER RISKS IN A-AQUIFER, CONSTRUCTION WORKER EXPOSURE SCENARIO

TMSRA for Parcel B

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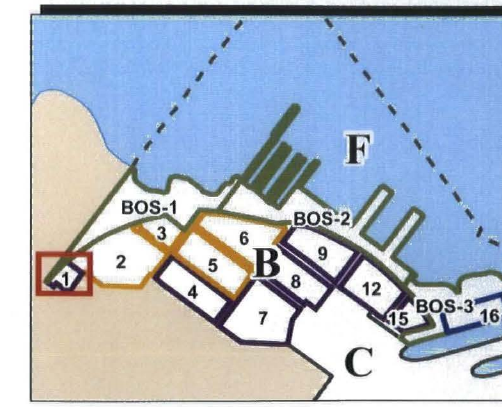

Location Map

- HHRA Sample Location
- Road
- Residential Cancer Risk > 1E-06
- Residential Cancer Risk ≤ 1E-06
- Residential Cancer Risk < 1E-06 (based on no detections)
- No Data
- Redevelopment Block 1
- Previous Excavation
- IR or SI Site
- Parcel Boundary
- Other Redevelopment Block
- Non-Navy Property

Notes:
1. A 50-foot by 50-foot exposure area (residential grid) is used to evaluate risks associated with residential exposures.
2. Risks are based on nonradiological chemicals.
3. No monitoring wells are located in this redevelopment block.

HHRA Human health risk assessment

N

0 30 60
Scale in Feet

ChaduxTt JV
Consulting Engineers and Scientists

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U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-11
BLOCK 1
HUMAN HEALTH RISK DRIVER
SOIL SAMPLE LOCATIONS
TMSRA for Parcel B

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FIGURE 3-12
(2 OF 5)

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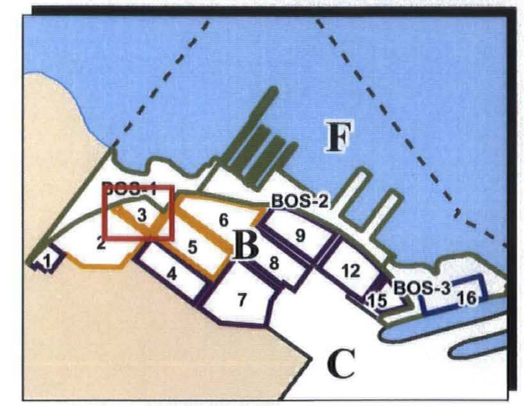

Location Map

★ Residential Lead Concentration > 155 mg/kg
● HHRA Risk Driver Sample Location
● HHRA Sample Location
RAMP Monitoring Well
Road
Residential Cancer Risk > 1E-06
Residential Cancer Risk ≤ 1E-06
Residential Cancer Risk < 1E-06 (based on no detections)
Highest Segregated Hazard Index > 1
No Data
Redevelopment Block 3
Previous Excavation
IR or SI Site
Other Redevelopment Block

Notes:
1. A 50-foot by 50-foot exposure area (residential grid) is used to evaluate risks associated with research and development exposures.
2. Risks are based on nonradiological chemicals.

HHRA Human health risk assessment
mg/kg Milligram per kilogram

N

0 40 80

Scale in Feet

ChaduxTt JV
Consulting Engineers and Scientists

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U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-13
BLOCK 3
HUMAN HEALTH RISK DRIVER
SOIL SAMPLE LOCATIONS
TMSRA for Parcel B

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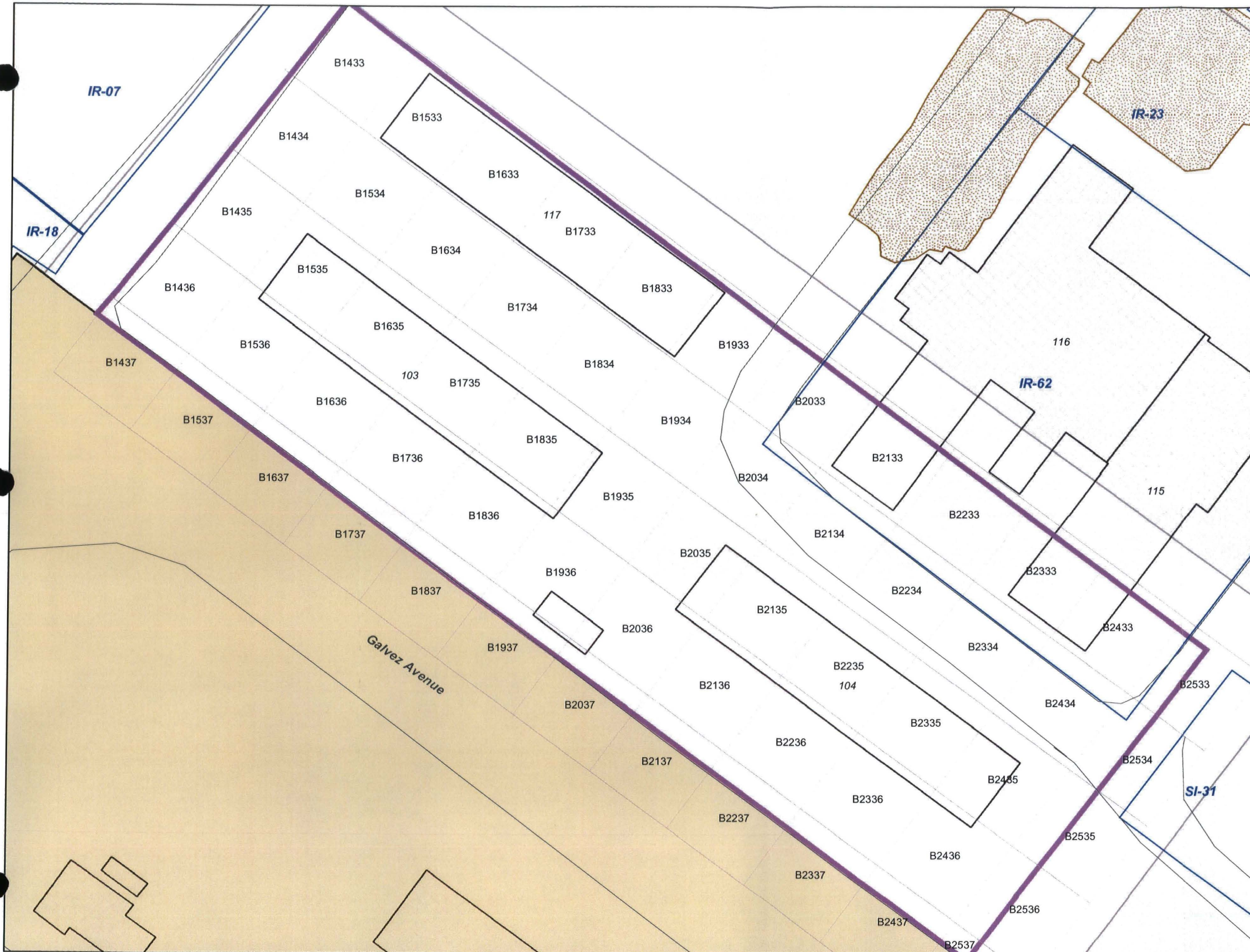

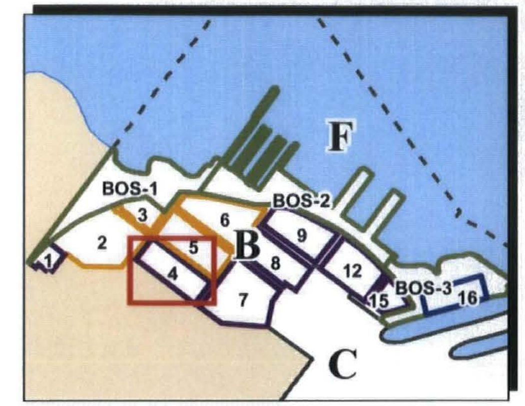

Location Map

- Road
- Previous Excavation
- Redevelopment Block 4
- IR or SI Site
- Parcel Boundary
- 116 Building
- Other Redevelopment Block
- Non-Navy Property

Notes:
1. A 50-foot by 50-foot exposure area (residential grid) is used to evaluate risks associated with residential exposures.
2. No human health risk assessment data in Redevelopment Block 4
3. No monitoring wells are located in this redevelopment block.

N

0 50 100

Scale in Feet

ChaduxTt JV

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FIGURE 3-14
BLOCK 4
HUMAN HEALTH RISK DRIVER
SOIL SAMPLE LOCATIONS

TMSRA for Parcel B

11/06/2007 O:\Hunters_Point\Projects\Parcel_B\Parcel_B_TMSRA\projects\fig3-14_Risk_Drivers_Blk4.mxd TtEMI-DN Kurt.Cholak

FIGURE 3-15
BLOCK 5
HUMAN HEALTH RISK DRIVER SOIL SAMPLE LOCATIONS
TMSRA for Parcel B

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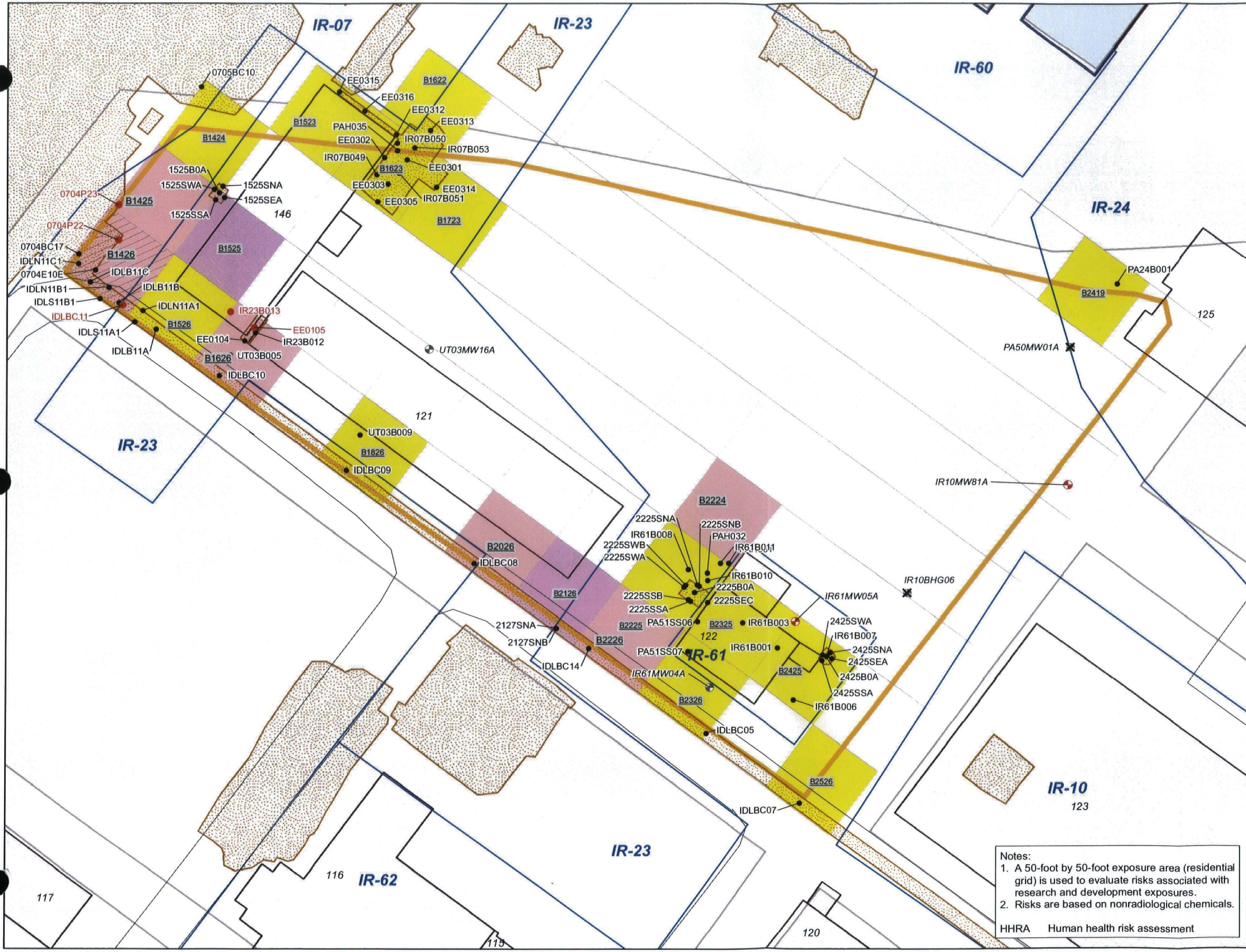

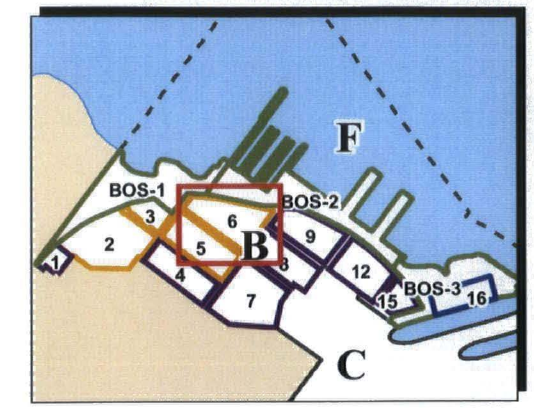

Location Map

- HHRA Risk Driver Sample Location
- HHRA Sample Location
- RAMP Monitoring Well
- Active Monitoring Well
- Decommissioned Monitoring Well
- Road
- Residential Cancer Risk > 1E-06
- Residential Cancer Risk ≤ 1E-06
- Residential Cancer Risk < 1E-06 (based on no detections)
- Highest Segregated Hazard Index > 1
- No Data
- Redevelopment Block 6
- Previous Excavation
- IR or SI Site
- Parcel Boundary
- 125 Building
- Other Redevelopment Block

N

0 60 120
Scale in Feet

ChaduxTt JV
Consulting Engineers and Scientists

Notes:
1. A 50-foot by 50-foot exposure area (residential grid) is used to evaluate risks associated with research and development exposures.
2. Risks are based on nonradiological chemicals.

HHRA Human health risk assessment

Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-16
BLOCK 6
HUMAN HEALTH RISK DRIVER
SOIL SAMPLE LOCATIONS
TMSRA for Parcel B

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Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-17
BLOCK 7
HUMAN HEALTH RISK DRIVER SOIL SAMPLE LOCATIONS

TMSRA for Parcel B

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FIGURE 3-18

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FIGURE 3-19
BLOCK 9
HUMAN HEALTH RISK DRIVER SOIL SAMPLE LOCATIONS

TMSRA for Parcel B

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FIGURE 3-20
(5 OF 5)

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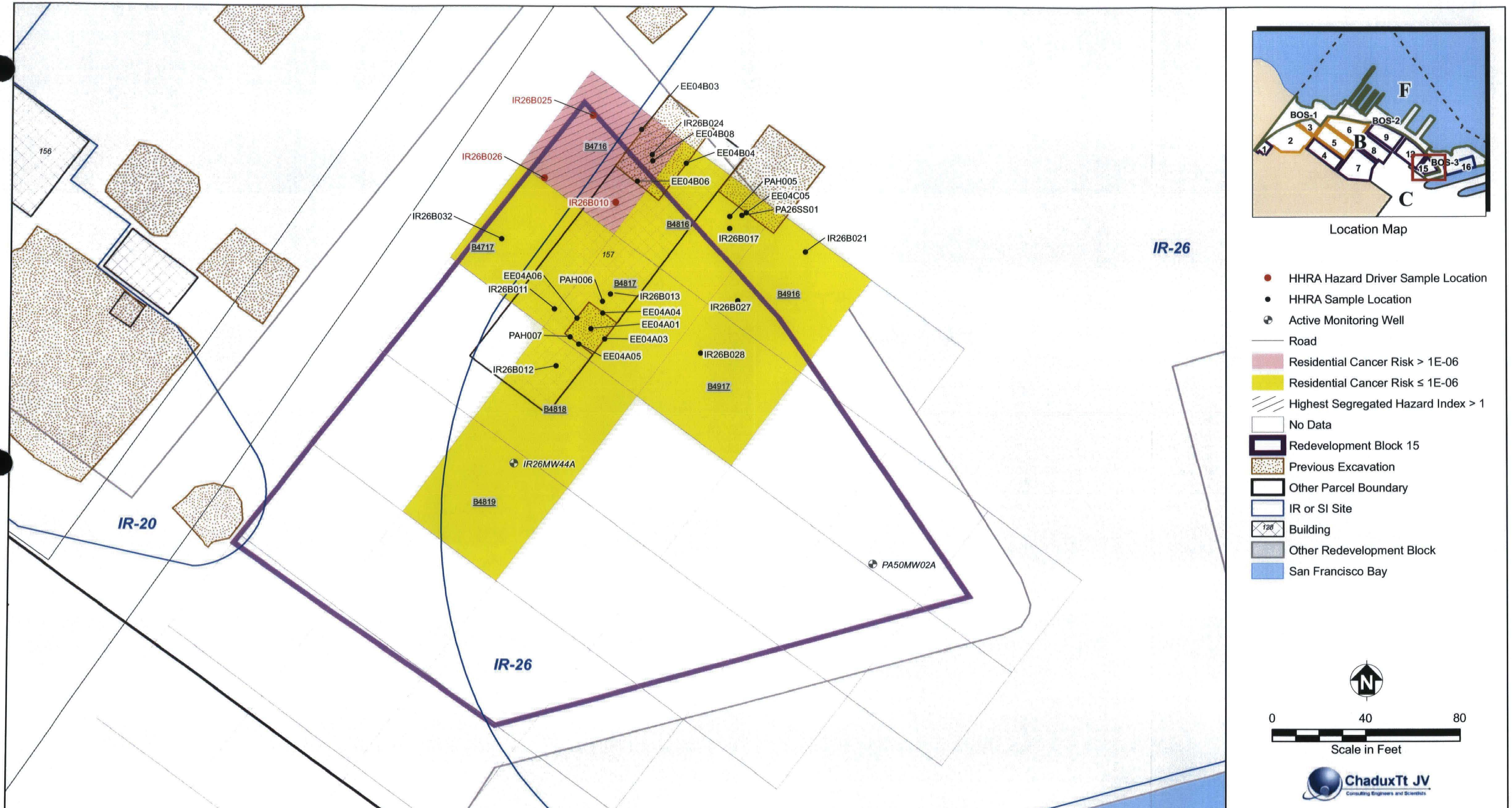

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U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-21
BLOCK 15
HUMAN HEALTH RISK DRIVER
SOIL SAMPLE LOCATIONS

TMSRA for Parcel B

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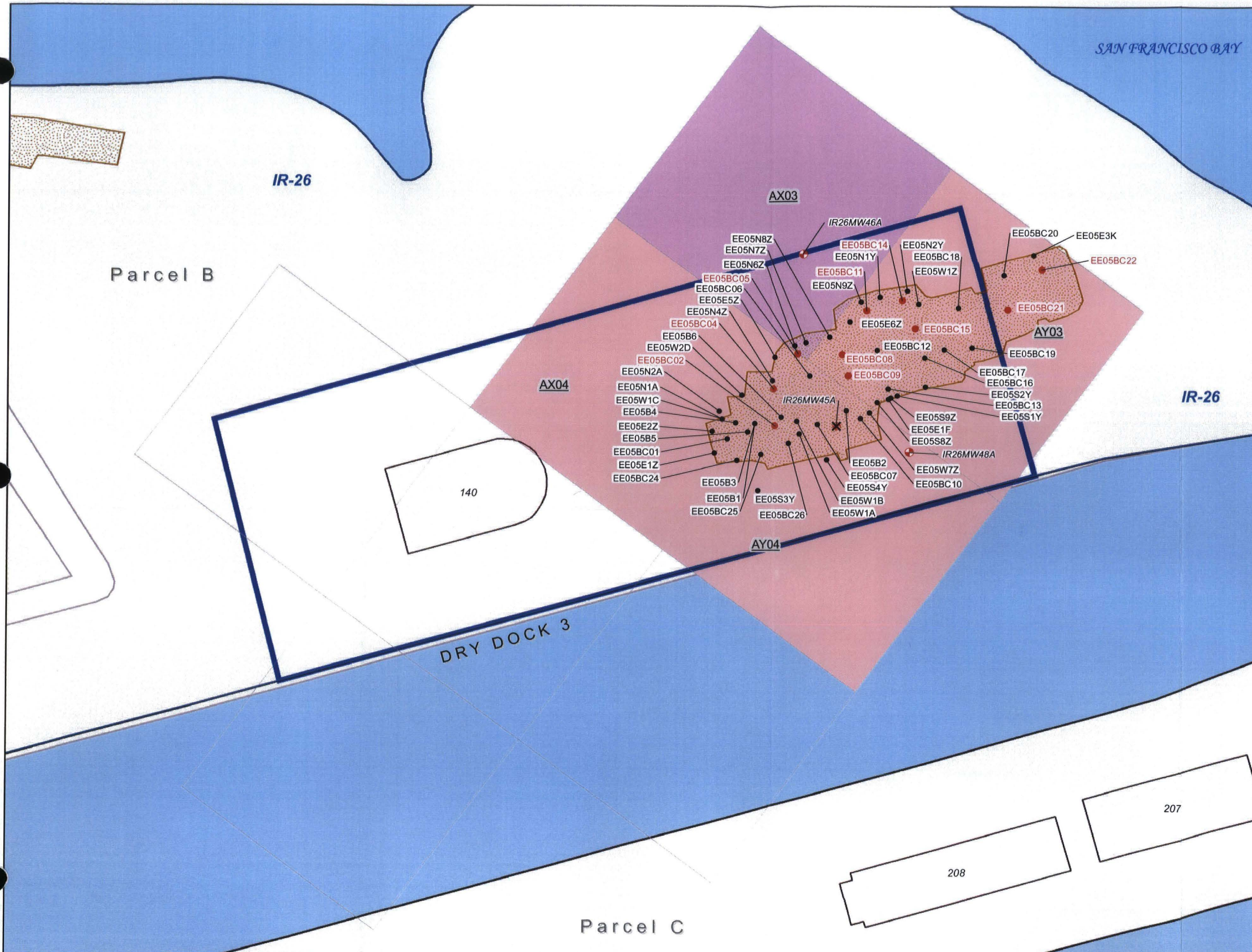
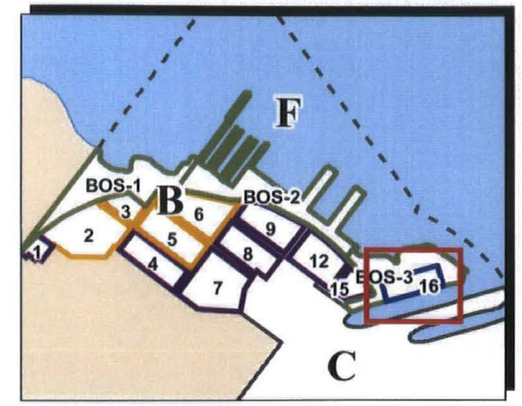




Location Map

- HHRA Hazard Driver Sample Location
- HHRA Sample Location
- RAMP Monitoring Well
- Former RAMP Monitoring Well
- Road
- Industrial Cancer Risk > 1E-06
- Industrial Cancer Risk < 1E-06 (based on no detections)
- No Data
- Redevelopment Block 16
- Previous Excavation
- IR or SI Site
- 140 Building
- Other Redevelopment Blocks
- Parcel Boundary
- Non-Navy Property
- San Francisco Bay

Notes:

1. A 150-foot by 150-foot exposure area (industrial grid) is used to evaluate risks associated with Educational/Cultural and Open Space planned reuses.
2. Risks are based on nonradiological chemicals.

HHRA Human health risk assessment

N

0 60 120

Scale in Feet

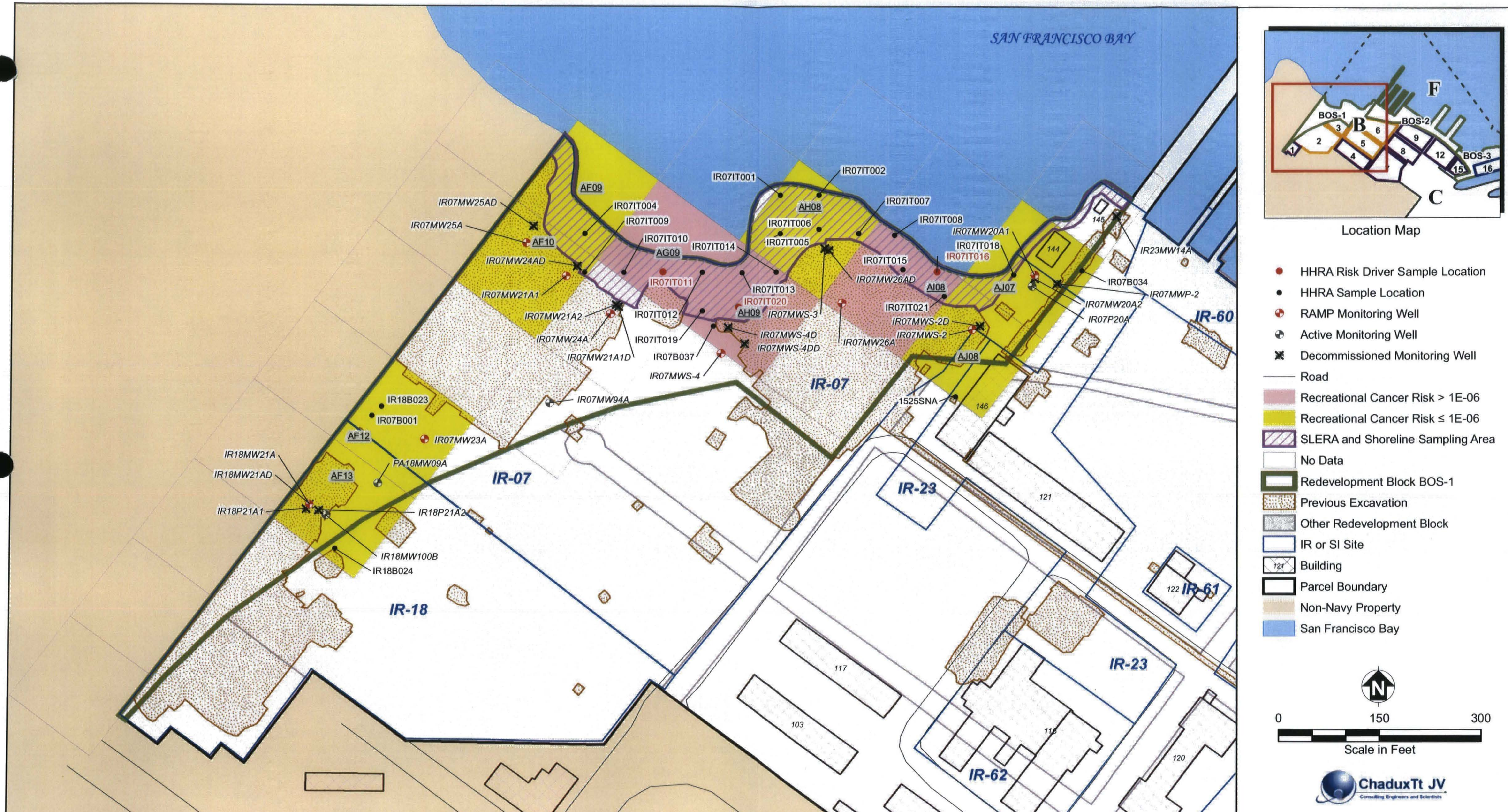
ChaduxTt JV

Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

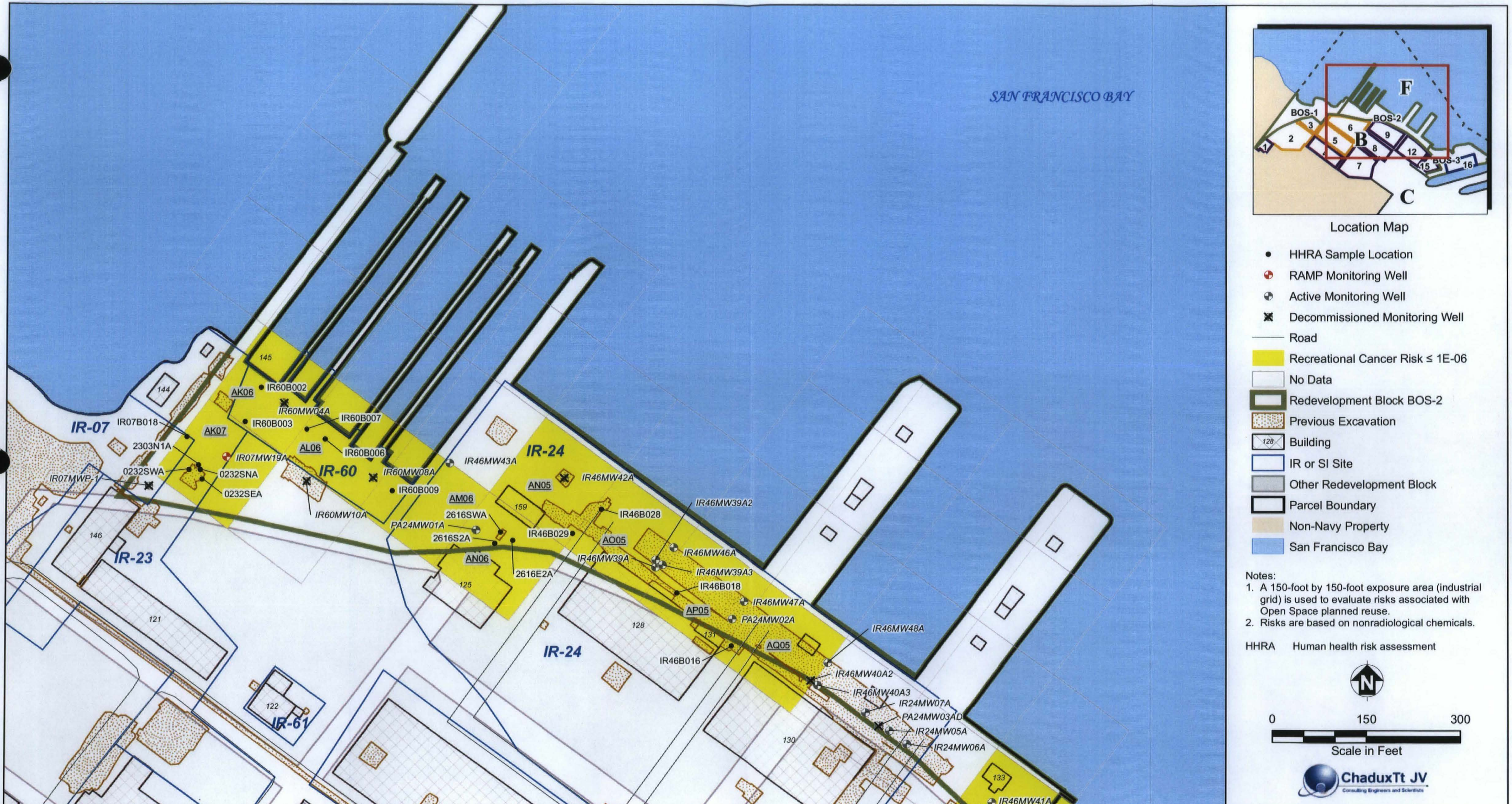
FIGURE 3-22
BLOCK 16
HUMAN HEALTH RISK DRIVER
SOIL SAMPLE LOCATIONS

TMSRA for Parcel B



Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-23
BLOCK BOS-1
HUMAN HEALTH RISK DRIVER
SOIL SAMPLE LOCATIONS
TMSRA for Parcel B



Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 3-24
BLOCK BOS-2
HUMAN HEALTH RISK DRIVER
SOIL SAMPLE LOCATIONS

TMSRA for Parcel B

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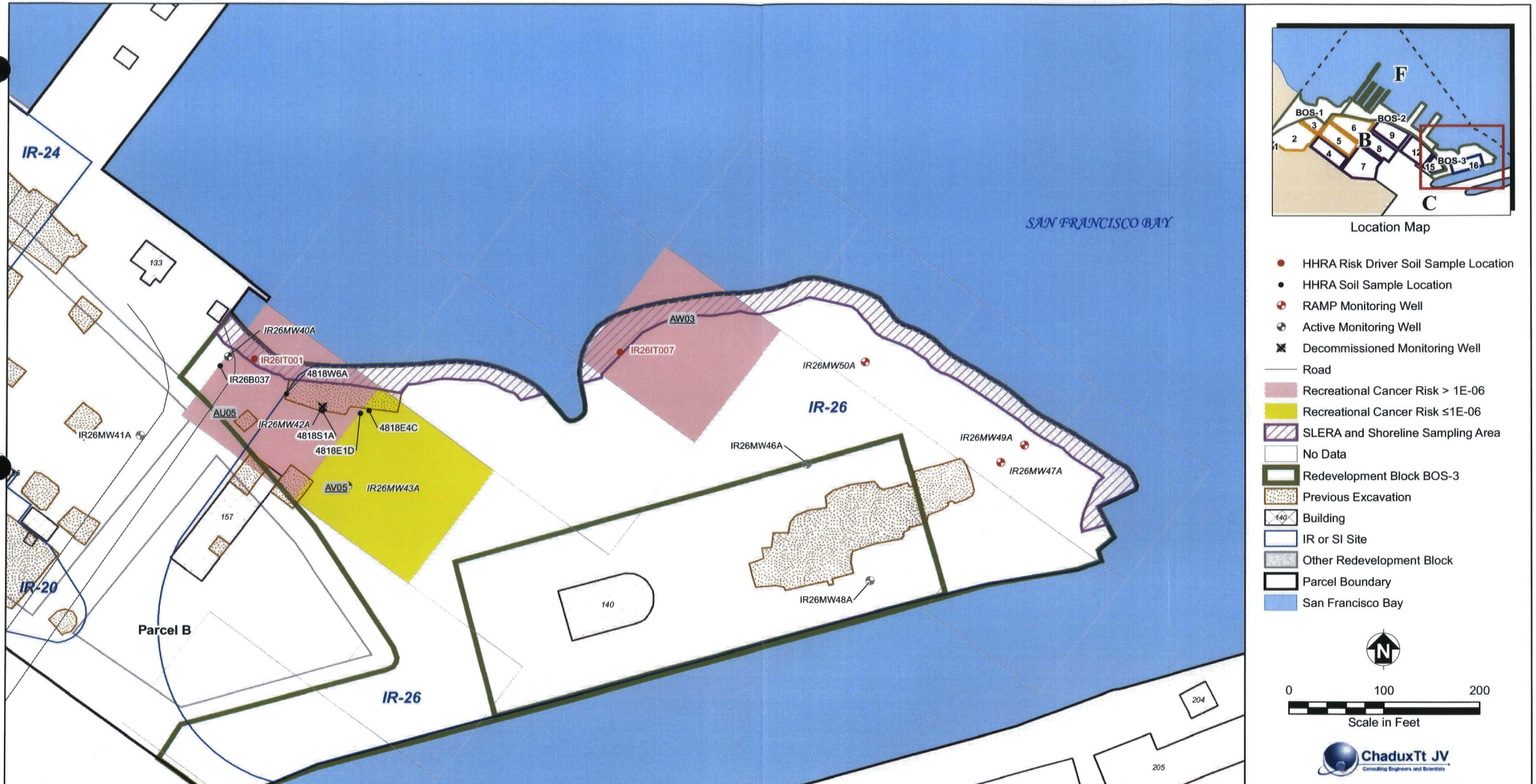

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FIGURE 3-25
BLOCK BOS-3
HUMAN HEALTH RISK DRIVER SOIL SAMPLE LOCATIONS AND ECOLOGICAL RISK DRIVER GROUNDWATER SAMPLE LOCATIONS

TMSRA for Parcel B

11/06/2007 O:\Hunters_Point\Projects\Parcel_B\Parcel_B_TMSRA\data\fig3-25_Risk_Drivers_BlkBOS-3.mxd TtEMI-DN Kurt.Cholak

TABLES

TABLE 3-1: HUMAN HEALTH RISK ASSESSMENT POTENTIAL COMPLETE EXPOSURE PATHWAYS

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

		Soil								Groundwater							
		0 to 2 feet				0 to 10 feet				A-Aquifer					B-Aquifer and Bedrock		
Exposure Scenario	Grid Size	Ingestion	Dermal	Inhalation (particulates and VOCs)	Home-grown Produce	Ingestion	Dermal	Inhalation (particulates and VOCs)	Home-grown Produce	Ingestion	Dermal	Inhalation (house-hold use)	Inhalation (vapor intrusion)	Inhalation (construction trench)	Ingestion	Dermal	Inhalation (house-hold use)
Residential	2,500 square feet	●	●	●	●	●	●	●	●	–	–	–	●	–	●[a]	●[a,b]	●[a]
Industrial	0.5 acre	●	●	●	–	●	●	●	–	–	–	–	●	–	–	–	–
Recreational	0.5 acre	●	●	●	–	–	–	–	–	–	–	–	–	–	–	–	–
Construction	0.5 acre	–	–	–	–	●	●	●	–	–	●	–	–	●	–	–	–

Notes:

–	Not quantitatively evaluated in HHRA
●	Quantitatively evaluated in HHRA
a	Although groundwater domestic use exposure pathways are incomplete for the A-aquifer, to address the potential for exposure resulting from hydraulic communication between the A- and B-aquifers for exposure areas B0139 and B0237, A-aquifer data were used to evaluate potential risks for these exposure areas.
b	Addressed in Uncertainty Analysis (see Section A9.0)
HHRA	Human health risk assessment
VOC	Volatile organic compound

TABLE 3-2: TOTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SURFACE SOIL (0 TO 2 FEET BGS)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
2	RD	B0336	**1E-04**	5E+00	<1
2	RD	B0339	**1E-04**	4E+00	<1
2	RD	B0538	4E-08	3E+00	<1
2	RD	B0640	9E-08	6E+00	**2E+00**
3	RD	B0929	1E-07	5E+00	<1
3	RD	B1028	**1E-04**	1E+01	**8E+00**
3	RD	B1029	**1E-04**	4E+00	<1
3	RD	B1129	**1E-04**	5E+00	**2E+00**
3	RD	B1130	**1E-04**	9E+00	**2E+00**
3	RD	B1131	**2E-04**	1E+01	**3E+00**
3	RD	B1231	**2E-04**	7E+00	**2E+00**
3	RD	B1330	**3E-04**	9E+00	**2E+00**
3	RD	B1331	**1E-04**	6E+00	**2E+00**
5	RD	B1632	**1E-04**	2E+00	<1
5	RD	B2129	2E-07	7E+00	**5E+00**
5	RD	B2130	2E-07	8E+00	**4E+00**
5	RD	B2132	1E-07	7E+00	**3E+00**
5	RD	B2232	**2E-04**	2E+00	<1
5	RD	B2332	3E-07	1E+01	**8E+00**
6	RD	B1424	7E-07	<1	<1
6	RD	B1425	--	<1	<1
6	RD	B1525	7E-11	<1	<1
6	RD	B1626	**5E-05**	9E+00	**4E+00**
6	RD	B2224	**6E-06**	--	--
6	RD	B2225	4E-07	1E+01	**6E+00**
6	RD	B2325	2E-07	8E+00	**5E+00**
6	RD	B2326	**9E-05**	5E+00	<1
6	RD	B2425	**1E-04**	1E+01	**3E+00**
7	MU	B3228	**2E-04**	1E+01	**3E+00**
7	MU	B3229	**2E-04**	8E+00	**2E+00**
7	MU	B3433	**7E-05**	4E+00	<1
7	MU	B3434	**1E-04**	4E+00	<1
8	MU	B3426	**7E-05**	4E+00	<1
8	MU	B3623	2E-07	<1	<1
8	MU	B2624	**9E-05**	7E+00	**3E+00**
8	MU	B2625	**9E-05**	6E+00	**3E+00**
8	MU	B2722	**1E-04**	4E+00	<1
8	MU	B2723	**2E-06**	<1	<1
8	MU	B2922	**1E-04**	6E+00	**2E+00**
8	MU	B2923	2E-07	6E+00	**3E+00**
8	MU	B2926	**2E-04**	7E+00	**2E+00**
8	MU	B3124	1E-06	--	--
8	MU	B3126	**1E-04**	2E+00	<1
9	MU	B2818	**2E-06**	--	--
9	MU	B2921	2E-07	8E+00	**5E+00**
9	MU	B3118	2E-07	9E+00	**3E+00**
9	MU	B3315	**1E-04**	8E+00	**3E+00**
9	MU	B3415	2E-07	9E+00	**3E+00**
9	MU	B3520	9E-08	7E+00	**2E+00**

TABLE 3-2: TOTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SURFACE SOIL (0 TO 2 FEET BGS) (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
12	MU	B3917	--	<1	<1
12	MU	B4019	**7E-05**	2E+00	<1
12	MU	B4116	--	<1	<1
12	MU	B4218	9E-09	2E+00	<1
12	MU	B4220	--	3E+00	**2E+00**
12	MU	B4319	--	<1	<1
12	MU	B4320	--	2E+00	<1
12	MU	B4321	--	<1	<1
12	MU	B4415	3E-08	4E+00	**2E+00**
12	MU	B4515	**9E-05**	6E+00	**2E+00**
12	MU	B4517	**1E-04**	5E+00	**2E+00**
12	MU	B4521	**7E-05**	5E+00	<1
12	MU	B4615	**1E-04**	8E+00	**3E+00**
15	MU	B4716	**1E-04**	9E+00	**2E+00**
15	MU	B4717	**2E-05**	4E+00	<1
15	MU	B4816	**6E-05**	6E+00	**2E+00**
15	MU	B4817	**9E-05**	5E+00	<1
15	MU	B4819	**9E-05**	4E+00	<1
15	MU	B4916	**2E-05**	8E+00	**3E+00**
BOS-1	OS	AF09	**7E-06**	<1	<1
BOS-1	OS	AF10	**6E-06**	<1	<1
BOS-1	OS	AF12	**2E-05**	<1	<1
BOS-1	OS	AF13	**1E-05**	<1	<1
BOS-1	OS	AG09	**1E-05**	<1	<1
BOS-1	OS	AH08	**1E-05**	<1	<1
BOS-1	OS	AH09	**2E-05**	<1	<1
BOS-1	OS	AI08	**2E-05**	<1	<1
BOS-1	OS	AJ07	**1E-05**	<1	<1
BOS-1	OS	AJ08	2E-07	<1	<1
BOS-2	OS	AK06	**2E-05**	<1	<1
BOS-2	OS	AK07	2E-11	<1	<1
BOS-2	OS	AL06	**3E-05**	<1	<1
BOS-2	OS	AM06	**7E-06**	<1	<1
BOS-2	OS	AN05	3E-09	<1	<1
BOS-2	OS	AN06	7E-09	<1	<1
BOS-2	OS	AO05	**1E-05**	<1	<1
BOS-2	OS	AP05	**1E-05**	<1	<1
BOS-2	OS	AQ05	1E-08	<1	<1
BOS-2	OS	AT05	**9E-06**	<1	<1
BOS-3	OS	AU05	**2E-05**	2E+00	<1
BOS-3	OS	AV05	**2E-05**	<1	<1
BOS-3	OS	AW03	**8E-05**	2E+00	<1

TABLE 3-2: TOTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SURFACE SOIL (0 TO 2 FEET BGS) (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Notes: Values shown in boldface exceed the threshold level of 1E-06 for cancer risks and 1.0 for segregated noncancer hazards.

--	Not applicable
bgs	Below ground surface
MU	Mixed use (residential exposure scenario)
OS	Open space (recreational exposure scenario)
RD	Research and development (residential exposure scenario)
RME	Reasonable maximum exposure

TABLE 3-3: TOTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SUBSURFACE SOIL (0 TO 10 FEET BGS)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
1	MU	B0143	**2E-06**	--	--
1	MU	B0144	**2E-06**	--	--
1	MU	B0145	4E-08	--	--
1	MU	B0146	2E-10	<1	<1
1	MU	B0243	4E-07	--	--
1	MU	B0245	3E-09	--	--
1	MU	B0344	3E-09	--	--
1	MU	B0345	5E-09	--	--
2	RD	B0142	**9E-06**	<1	<1
2	RD	B0238	**2E-06**	<1	<1
2	RD	B0239	**2E-06**	<1	<1
2	RD	B0240	**3E-06**	<1	<1
2	RD	B0241	**7E-06**	<1	<1
2	RD	B0242	**9E-06**	<1	<1
2	RD	B0336	**2E-04**	6E+00	<1
2	RD	B0337	5E-07	<1	<1
2	RD	B0339	**1E-04**	9E+00	**4E+00**
2	RD	B0340	1E-06	<1	<1
2	RD	B0341	**3E-06**	<1	<1
2	RD	B0342	4E-09	--	--
2	RD	B0434	**2E-04**	<1	<1
2	RD	B0437	7E-07	<1	<1
2	RD	B0438	3E-07	<1	<1
2	RD	B0441	1E-06	<1	<1
2	RD	B0442	3E-07	<1	<1
2	RD	B0533	**7E-05**	<1	<1
2	RD	B0536	6E-08	<1	<1
2	RD	B0538	1E-07	8E+00	**3E+00**
2	RD	B0636	**2E-04**	<1	<1
2	RD	B0638	**2E-06**	<1	<1
2	RD	B0640	4E-07	1E+01	**7E+00**
2	RD	B0738	8E-08	<1	<1
2	RD	B1035	4E-07	<1	<1
2	RD	B1036	**3E-06**	<1	<1
2	RD	B1133	--	<1	<1
2	RD	B1138	2E-08	<1	<1
3	RD	B0532	**4E-05**	<1	<1
3	RD	B0632	**6E-05**	1E+01	**9E+00**
3	RD	B0928	**9E-05**	7E+00	**2E+00**
3	RD	B0929	9E-07	6E+00	<1
3	RD	B0930	4E-08	<1	<1
3	RD	B1028	**2E-04**	2E+01	**7E+00**
3	RD	B1029	**5E-04**	1E+01	**6E+00**
3	RD	B1030	**2E-04**	4E+00	<1
3	RD	B1128	**2E-04**	7E+00	**2E+00**
3	RD	B1129	**2E-04**	2E+01	**7E+00**
3	RD	B1130	**3E-04**	2E+01	**6E+00**
3	RD	B1131	**3E-04**	1E+01	**4E+00**
3	RD	B1132	--	<1	<1

TABLE 3-3: TOTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SUBSURFACE SOIL (0 TO 10 FEET BGS) (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
3	RD	B1228	**2E-04**	6E+00	<1
3	RD	B1229	**2E-04**	7E+00	**2E+00**
3	RD	B1230	**2E-04**	8E+00	**2E+00**
3	RD	B1231	**2E-04**	7E+00	**2E+00**
3	RD	B1328	**2E-04**	2E+01	**9E+00**
3	RD	B1329	**2E-04**	8E+00	**2E+00**
3	RD	B1330	**3E-03**	2E+01	**8E+00**
3	RD	B1331	**1E-03**	1E+01	**3E+00**
5	RD	B1427	--	<1	<1
5	RD	B1527	9E-08	5E+00	**2E+00**
5	RD	B1628	3E-07	9E+00	**6E+00**
5	RD	B1632	**1E-04**	2E+00	<1
5	RD	B1727	3E-07	9E+00	**5E+00**
5	RD	B1728	2E-07	8E+00	**4E+00**
5	RD	B1729	2E-07	6E+00	**3E+00**
5	RD	B1928	**2E-04**	1E+01	**3E+00**
5	RD	B1930	**1E-04**	7E+00	**4E+00**
5	RD	B1931	2E-07	7E+00	**3E+00**
5	RD	B2028	1E-07	<1	<1
5	RD	B2030	3E-07	9E+00	**6E+00**
5	RD	B2032	3E-07	1E+01	**6E+00**
5	RD	B2127	**2E-06**	<1	<1
5	RD	B2128	**3E-06**	<1	<1
5	RD	B2129	**4E-05**	1E+01	**6E+00**
5	RD	B2130	4E-07	1E+01	**8E+00**
5	RD	B2131	3E-07	1E+01	**6E+00**
5	RD	B2132	1E-07	7E+00	**3E+00**
5	RD	B2228	**4E-06**	<1	<1
5	RD	B2230	**2E-05**	6E+00	**2E+00**
5	RD	B2232	**2E-04**	1E+01	**6E+00**
5	RD	B2332	4E-07	1E+01	**8E+00**
6	RD	B1424	9E-07	<1	<1
6	RD	B1425	**1E-04**	1E+01	**4E+00**
6	RD	B1426	**2E-04**	1E+01	**4E+00**
6	RD	B1523	**1E-04**	8E+00	**3E+00**
6	RD	B1525	7E-11	<1	<1
6	RD	B1526	--	<1	<1
6	RD	B1622	**1E-04**	6E+00	**2E+00**
6	RD	B1623	**1E-04**	1E+01	**4E+00**
6	RD	B1626	**7E-05**	1E+01	**4E+00**
6	RD	B1723	**1E-04**	6E+00	**2E+00**
6	RD	B1826	**1E-04**	1E+01	**4E+00**
6	RD	B2026	**1E-04**	5E+00	<1
6	RD	B2224	**6E-06**	--	--
6	RD	B2225	4E-07	1E+01	**5E+00**
6	RD	B2226	**1E-04**	5E+00	**2E+00**
6	RD	B2325	3E-07	9E+00	**5E+00**
6	RD	B2326	**9E-05**	1E+01	**5E+00**
6	RD	B2419	**2E-04**	1E+01	**7E+00**

TABLE 3-3: TOTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SUBSURFACE SOIL (0 TO 10 FEET BGS) (CONTINUED)
Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
6	RD	B2425	**8E-05**	1E+01	**5E+00**
6	RD	B2526	**7E-05**	6E+00	**2E+00**
7	MU	B2635	**9E-05**	4E+00	**3E+00**
7	MU	B2727	**3E-04**	1E+01	**3E+00**
7	MU	B2735	**4E-04**	6E+00	**3E+00**
7	MU	B2835	**1E-04**	2E+00	<1
7	MU	B3127	**1E-04**	2E+00	**2E+00**
7	MU	B3128	**1E-04**	2E+00	**2E+00**
7	MU	B3228	**2E-04**	1E+01	**5E+00**
7	MU	B3229	**2E-04**	8E+00	**2E+00**
7	MU	B3328	1E-07	6E+00	**3E+00**
7	MU	B3433	**9E-05**	5E+00	<1
7	MU	B3434	**9E-05**	4E+00	<1
8	MU	B2623	5E-07	<1	<1
8	MU	B2624	**1E-04**	9E+00	**4E+00**
8	MU	B2625	**9E-05**	9E+00	**5E+00**
8	MU	B2722	**1E-04**	1E+01	**4E+00**
8	MU	B2723	**1E-05**	2E+00	**2E+00**
8	MU	B2724	**3E-05**	<1	<1
8	MU	B2725	5E-07	7E+00	**3E+00**
8	MU	B2726	**7E-05**	9E+00	**4E+00**
8	MU	B2823	**2E-04**	1E+01	**4E+00**
8	MU	B2824	**1E-05**	<1	<1
8	MU	B2826	--	<1	<1
8	MU	B2922	**1E-04**	8E+00	**3E+00**
8	MU	B2923	**2E-04**	2E+01	**1E+01**
8	MU	B2924	**9E-05**	<1	<1
8	MU	B2925	**7E-05**	<1	<1
8	MU	B2926	**2E-04**	1E+01	**3E+00**
8	MU	B3023	9E-09	<1	<1
8	MU	B3024	2E-08	<1	<1
8	MU	B3026	--	<1	<1
8	MU	B3124	1E-06	--	--
8	MU	B3126	**9E-05**	1E+01	**7E+00**
8	MU	B3226	--	<1	<1
8	MU	B3324	--	--	--
8	MU	B3326	**7E-05**	1E+01	**5E+00**
8	MU	B3422	**3E-06**	<1	<1
8	MU	B3423	**1E-04**	7E+00	**2E+00**
8	MU	B3425	1E-07	8E+00	**3E+00**
8	MU	B3426	**2E-04**	1E+01	**7E+00**
8	MU	B3522	--	<1	<1
8	MU	B3525	--	<1	<1
8	MU	B3622	6E-07	2E+00	**2E+00**
8	MU	B3623	2E-07	<1	<1
9	MU	B2716	3E-07	8E+00	**6E+00**
9	MU	B2818	**2E-06**	--	--
9	MU	B2918	**1E-04**	7E+00	**2E+00**
9	MU	B2921	**1E-04**	1E+01	**6E+00**

TABLE 3-3: TOTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SUBSURFACE SOIL (0 TO 10 FEET BGS) (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
9	MU	B3117	--	2E+00	**2E+00**
9	MU	B3118	**1E-04**	1E+01	**3E+00**
9	MU	B3215	**2E-04**	2E+00	<1
9	MU	B3217	--	2E+00	**2E+00**
9	MU	B3218	**8E-05**	2E+00	**2E+00**
9	MU	B3220	--	<1	<1
9	MU	B3315	**1E-04**	1E+01	**4E+00**
9	MU	B3316	9E-07	<1	<1
9	MU	B3415	**7E-05**	1E+01	**3E+00**
9	MU	B3418	**6E-05**	1E+01	**6E+00**
9	MU	B3421	**2E-04**	1E+01	**6E+00**
9	MU	B3515	**2E-04**	<1	<1
9	MU	B3516	**1E-04**	8E+00	**2E+00**
9	MU	B3520	3E-07	1E+01	**6E+00**
9	MU	B3615	--	<1	<1
12	MU	B3715	**2E-04**	<1	<1
12	MU	B3718	**3E-04**	1E+01	**5E+00**
12	MU	B3815	1E-06	5E+00	**4E+00**
12	MU	B3816	**2E-04**	8E+00	**2E+00**
12	MU	B3817	--	<1	<1
12	MU	B3915	**2E-04**	9E+00	**3E+00**
12	MU	B3916	5E-10	2E+00	**2E+00**
12	MU	B3917	**6E-06**	<1	<1
12	MU	B3918	--	<1	<1
12	MU	B3919	**3E-06**	2E+00	<1
12	MU	B3920	6E-07	--	--
12	MU	B4015	1E-06	2E+00	**2E+00**
12	MU	B4016	**2E-06**	2E+00	<1
12	MU	B4017	**2E-04**	3E+00	**2E+00**
12	MU	B4018	4E-07	2E+00	<1
12	MU	B4019	**9E-05**	7E+00	**3E+00**
12	MU	B4020	7E-08	3E+00	**3E+00**
12	MU	B4115	**2E-05**	2E+00	<1
12	MU	B4116	**2E-05**	3E+00	**3E+00**
12	MU	B4117	6E-07	<1	<1
12	MU	B4215	1E-06	<1	<1
12	MU	B4217	**9E-05**	5E+00	**2E+00**
12	MU	B4218	**8E-05**	7E+00	**2E+00**
12	MU	B4219	**1E-04**	7E+00	**2E+00**
12	MU	B4220	**2E-04**	9E+00	**3E+00**
12	MU	B4315	**3E-04**	1E+01	**3E+00**
12	MU	B4319	--	<1	<1
12	MU	B4320	**8E-05**	8E+00	**2E+00**
12	MU	B4321	--	<1	<1
12	MU	B4415	3E-08	5E+00	**2E+00**
12	MU	B4417	--	<1	<1
12	MU	B4418	4E-07	<1	<1
12	MU	B4419	8E-07	<1	<1
12	MU	B4420	5E-07	<1	<1

TABLE 3-3: TOTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SUBSURFACE SOIL (0 TO 10 FEET BGS) (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
12	MU	B4421	7E-07	<1	<1
12	MU	B4515	**9E-05**	6E+00	**2E+00**
12	MU	B4517	**2E-04**	7E+00	**3E+00**
12	MU	B4518	5E-07	<1	<1
12	MU	B4519	4E-07	<1	<1
12	MU	B4520	**4E-06**	<1	<1
12	MU	B4521	**7E-05**	5E+00	<1
12	MU	B4615	**1E-04**	8E+00	**3E+00**
12	MU	B4616	2E-07	8E+00	**4E+00**
12	MU	B4617	**9E-05**	7E+00	**3E+00**
12	MU	B4620	4E-08	<1	<1
12	MU	B4621	8E-07	5E+00	**2E+00**
15	MU	B4716	**2E-04**	2E+01	**1E+01**
15	MU	B4717	**9E-05**	5E+00	<1
15	MU	B4816	**9E-05**	6E+00	**2E+00**
15	MU	B4817	**9E-05**	5E+00	<1
15	MU	B4818	**1E-04**	7E+00	**2E+00**
15	MU	B4819	**9E-05**	4E+00	<1
15	MU	B4916	**7E-05**	8E+00	**3E+00**
15	MU	B4917	**7E-05**	6E+00	**2E+00**
16	E/C	AX04	**1E-04**	<1	<1
16	E/C	AY03	**6E-05**	<1	<1
16	E/C	AY04	**1E-05**	<1	<1

Notes: Values shown in boldface exceed the threshold level of 1E-06 for cancer risks and 1.0 for segregated noncancer hazards.

--	Not applicable
bgs	Below ground surface
E/C	Educational/cultural (industrial exposure scenario)
MU	Mixed use (residential exposure scenario)
RD	Research and development (residential exposure scenario)
RME	Reasonable maximum exposure

TABLE 3-4: TOTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SURFACE SOIL (0 TO 10 FEET BGS), CONSTRUCTION WORKER

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
1	MU	AF15	1E-07	--	--
1	MU	AF16	4E-12	<1	<1
2	RD	AF14	**3E-06**	<1	<1
2	RD	AG12	**4E-06**	<1	<1
2	RD	AG13	9E-08	<1	<1
2	RD	AG14	7E-08	2E+00	<1
2	RD	AH13	2E-09	<1	<1
2	RD	AI12	2E-07	<1	<1
2	RD	AI13	3E-10	<1	<1
3	RD	AH10	**2E-06**	<1	<1
3	RD	AI10	**4E-06**	<1	<1
3	RD	AI11	**5E-06**	<1	<1
5	RD	AJ10	**2E-05**	2E+00	<1
5	RD	AJ11	**3E-05**	2E+00	<1
5	RD	AK10	5E-09	<1	<1
5	RD	AK11	**3E-06**	<1	<1
5	RD	AL10	**5E-06**	<1	<1
5	RD	AL11	5E-09	<1	<1
5	RD	AM10	7E-07	<1	<1
5	RD	AM11	**4E-06**	<1	<1
6	RD	AJ09	**3E-06**	<1	<1
6	RD	AK08	**3E-06**	<1	<1
6	RD	AK09	**2E-06**	<1	<1
6	RD	AL09	**3E-06**	<1	<1
6	RD	AM07	**4E-06**	<1	<1
6	RD	AM08	3E-07	--	--
6	RD	AM09	**2E-06**	<1	<1
7	MU	AN12	**7E-06**	<1	<1
7	MU	AO12	**3E-06**	<1	<1
7	MU	AP10	**3E-06**	<1	<1
7	MU	AQ11	**2E-06**	<1	<1
7	MU	AQ12	**2E-06**	<1	<1
8	MU	AN08	**3E-06**	<1	<1
8	MU	AN09	**7E-06**	<1	<1
8	MU	AO08	**6E-06**	2E+00	<1
8	MU	AO09	**5E-06**	<1	<1
8	MU	AP08	7E-08	--	--
8	MU	AP09	**2E-06**	<1	<1
8	MU	AQ08	**3E-06**	<1	<1
8	MU	AQ09	**4E-06**	<1	<1
9	MU	AO06	**3E-06**	<1	<1
9	MU	AO07	**2E-06**	<1	<1
9	MU	AP06	**3E-06**	2E+00	<1
9	MU	AP07	--	<1	<1
9	MU	AQ06	**2E-06**	<1	<1
9	MU	AQ07	**5E-06**	<1	<1

TABLE 3-4: TOTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SURFACE SOIL (0 TO 10 FEET BGS), CONSTRUCTION WORKER (CONTINUED)
Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
12	MU	AR06	**3E-06**	<1	<1
12	MU	AR07	2E-07	<1	<1
12	MU	AS06	**4E-06**	<1	<1
12	MU	AS07	**3E-06**	<1	<1
12	MU	AT06	**4E-06**	<1	<1
12	MU	AT07	**2E-06**	<1	<1
15	MU	AU06	**4E-06**	<1	<1
15	MU	AU07	**2E-06**	<1	<1
15	MU	AV06	**2E-06**	<1	<1
16	E/C	AX04	**4E-05**	2E+00	<1
16	E/C	AY03	**2E-05**	<1	<1
16	E/C	AY04	**4E-06**	<1	<1
BOS-1	OS	AE09	1E-07	<1	<1
BOS-1	OS	AE10	6E-07	<1	<1
BOS-1	OS	AE11	--	<1	<1
BOS-1	OS	AE13	4E-08	<1	<1
BOS-1	OS	AE14	2E-07	<1	<1
BOS-1	OS	AF09	**8E-06**	2E+00	<1
BOS-1	OS	AF10	**6E-06**	<1	<1
BOS-1	OS	AF11	**2E-06**	<1	<1
BOS-1	OS	AF12	**4E-06**	<1	<1
BOS-1	OS	AF13	**3E-06**	<1	<1
BOS-1	OS	AG09	**3E-06**	2E+00	<1
BOS-1	OS	AG10	**3E-06**	<1	<1
BOS-1	OS	AG11	**2E-06**	<1	<1
BOS-1	OS	AH08	**3E-06**	<1	<1
BOS-1	OS	AH09	**3E-06**	2E+00	<1
BOS-1	OS	AI08	**3E-06**	2E+00	<1
BOS-1	OS	AI09	**4E-06**	<1	<1
BOS-1	OS	AJ06	**3E-06**	<1	<1
BOS-1	OS	AJ07	**3E-06**	2E+00	<1
BOS-1	OS	AJ08	**4E-06**	5E+00	**3E+00**
BOS-2	OS	AK06	**7E-06**	<1	<1
BOS-2	OS	AK07	**3E-06**	<1	<1
BOS-2	OS	AL06	**4E-06**	<1	<1
BOS-2	OS	AL07	**4E-06**	<1	<1
BOS-2	OS	AM05	1E-06	<1	<1
BOS-2	OS	AM06	**3E-06**	<1	<1
BOS-2	OS	AN05	**6E-06**	<1	<1
BOS-2	OS	AN06	**3E-06**	<1	<1
BOS-2	OS	AO05	**3E-06**	<1	<1
BOS-2	OS	AP05	**3E-06**	<1	<1
BOS-2	OS	AQ05	**2E-06**	2E+00	<1
BOS-2	OS	AR05	**4E-06**	<1	<1
BOS-2	OS	AS05	**3E-06**	<1	<1
BOS-2	OS	AT05	**6E-06**	2E+00	<1

Table 3-4: Total Risk: Summary of Cancer Risks and Hazard Indices by Planned Reuse, Surface Soil (0 to 10 feet bgs), Construction Worker (Continued)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
BOS-3	OS	AU05	**4E-06**	3E+00	**2E+00**
BOS-3	OS	AV04	5E-08	<1	<1
BOS-3	OS	AV05	**4E-06**	<1	<1
BOS-3	OS	AW03	**2E-05**	4E+00	<1

Notes:	Values shown in boldface exceed the threshold level of 1E-06 for cancer risks and 1.0 for segregated noncancer hazards.
--	Not applicable
bgs	Below ground surface
E/C	Educational/cultural (industrial exposure scenario)
MU	Mixed use (residential exposure scenario)
OS	Open space (recreational exposure scenario)
RD	Research and development (residential exposure scenario)
RME	Reasonable maximum exposure

TABLE 3-8: INCREMENTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SURFACE SOIL (0 TO 2 FEET BGS)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
2	RD	B0336	5E-08	<1	<1
2	RD	B0339	6E-09	<1	<1
2	RD	B0538	--	<1	<1
2	RD	B0640	--	<1	<1
3	RD	B0929	8E-08	<1	<1
3	RD	B1028	**6E-06**	8E+00	**8E+00**
3	RD	B1029	**7E-06**	<1	<1
3	RD	B1129	3E-09	<1	<1
3	RD	B1130	**6E-06**	3E+00	**2E+00**
3	RD	B1131	**2E-05**	3E+00	**3E+00**
3	RD	B1231	**1E-05**	2E+00	**2E+00**
3	RD	B1330	**3E-04**	4E+00	**2E+00**
3	RD	B1331	9E-07	<1	<1
5	RD	B1632	9E-07	<1	<1
5	RD	B2129	--	<1	<1
5	RD	B2130	--	<1	<1
5	RD	B2132	--	<1	<1
5	RD	B2232	1E-09	<1	<1
5	RD	B2332	--	<1	<1
6	RD	B1424	7E-07	--	--
6	RD	B1626	**6E-06**	<1	<1
6	RD	B2224	**6E-06**	--	--
6	RD	B2225	4E-08	<1	<1
6	RD	B2325	--	<1	<1
6	RD	B2326	--	<1	<1
6	RD	B2425	2E-07	2E+00	<1
7	MU	B3228	1E-09	3E+00	**3E+00**
7	MU	B3229	--	2E+00	**2E+00**
7	MU	B3433	4E-08	<1	<1
7	MU	B3434	--	<1	<1
8	MU	B2624	--	<1	<1
8	MU	B2625	--	<1	<1
8	MU	B2722	5E-09	<1	<1
8	MU	B2723	**2E-06**	<1	<1
8	MU	B2922	1E-08	<1	<1
8	MU	B2923	1E-07	3E+00	**3E+00**
8	MU	B2926	1E-06	<1	<1
8	MU	B3124	1E-06	--	--
8	MU	B3126	--	--	--
8	MU	B3426	--	<1	<1
8	MU	B3623	2E-07	<1	<1
9	MU	B2818	**2E-06**	--	--
9	MU	B2921	--	<1	<1
9	MU	B3118	--	<1	<1
9	MU	B3315	3E-08	<1	<1
9	MU	B3415	--	<1	<1
9	MU	B3520	--	<1	<1
12	MU	B4218	--	<1	<1
12	MU	B4220	--	2E+00	**2E+00**
12	MU	B4415	--	<1	<1
12	MU	B4515	1E-07	<1	<1

TABLE 3-8: INCREMENTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SURFACE SOIL (0 TO 2 FEET BGS) (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
12	MU	B4517	--	<1	<1
12	MU	B4521	--	<1	<1
12	MU	B4615	--	3E+00	**3E+00**
15	MU	B4716	**4E-05**	4E+00	**2E+00**
15	MU	B4717	--	<1	<1
15	MU	B4816	5E-08	<1	<1
15	MU	B4817	--	<1	<1
15	MU	B4819	--	<1	<1
15	MU	B4916	--	<1	<1
BOS-1	OS	AF09	6E-07	<1	<1
BOS-1	OS	AF10	5E-07	<1	<1
BOS-1	OS	AF12	3E-08	<1	<1
BOS-1	OS	AF13	8E-10	<1	<1
BOS-1	OS	AG09	**3E-06**	<1	<1
BOS-1	OS	AH08	1E-06	<1	<1
BOS-1	OS	AH09	**8E-06**	<1	<1
BOS-1	OS	AI08	**4E-06**	<1	<1
BOS-1	OS	AJ07	1E-06	<1	<1
BOS-1	OS	AJ08	2E-07	--	--
BOS-2	OS	AK06	3E-07	<1	<1
BOS-2	OS	AK07	--	<1	<1
BOS-2	OS	AL06	--	<1	<1
BOS-2	OS	AM06	--	<1	<1
BOS-2	OS	AN05	--	<1	<1
BOS-2	OS	AN06	7E-09	<1	<1
BOS-2	OS	AO05	--	<1	<1
BOS-2	OS	AP05	9E-09	<1	<1
BOS-2	OS	AQ05	--	<1	<1
BOS-2	OS	AT05	2E-08	<1	<1
BOS-3	OS	AU05	**1E-05**	<1	<1
BOS-3	OS	AV05	6E-07	<1	<1
BOS-3	OS	AW03	**8E-05**	<1	<1

Notes: Values shown in boldface exceed the threshold level of 1E-06 for cancer risks and 1.0 for segregated noncancer hazards.

--	Not applicable
bgs	Below ground surface
MU	Mixed use (residential exposure scenario)
OS	Open space (recreational exposure scenario)
RD	Research and development (residential exposure scenario)
RME	Reasonable maximum exposure

TABLE 3-9: INCREMENTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SUBSURFACE SOIL (0 TO 10 FEET BGS)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
1	MU	B0143	**2E-06**	--	--
1	MU	B0144	**2E-06**	--	--
1	MU	B0145	4E-08	--	--
1	MU	B0146	--	<1	<1
1	MU	B0243	4E-07	--	--
1	MU	B0245	3E-09	--	--
1	MU	B0344	3E-09	--	--
1	MU	B0345	5E-09	--	--
2	RD	B0142	**9E-06**	<1	<1
2	RD	B0238	**2E-06**	<1	<1
2	RD	B0239	**2E-06**	<1	<1
2	RD	B0240	**3E-06**	<1	<1
2	RD	B0241	**7E-06**	<1	<1
2	RD	B0242	**9E-06**	<1	<1
2	RD	B0336	5E-08	<1	<1
2	RD	B0337	5E-07	<1	<1
2	RD	B0339	1E-06	<1	<1
2	RD	B0340	1E-06	<1	<1
2	RD	B0341	**3E-06**	<1	<1
2	RD	B0342	4E-09	--	--
2	RD	B0434	1E-07	<1	<1
2	RD	B0437	7E-07	<1	<1
2	RD	B0438	3E-07	<1	<1
2	RD	B0441	1E-06	<1	<1
2	RD	B0442	3E-07	<1	<1
2	RD	B0533	1E-06	--	--
2	RD	B0536	6E-08	<1	<1
2	RD	B0538	--	3E+00	**2E+00**
2	RD	B0636	--	--	--
2	RD	B0638	**2E-06**	<1	<1
2	RD	B0640	--	<1	<1
2	RD	B0738	8E-08	<1	<1
2	RD	B1035	4E-07	<1	<1
2	RD	B1036	**3E-06**	<1	<1
3	RD	B0532	**4E-06**	<1	<1
3	RD	B0632	5E-09	3E+00	**3E+00**
3	RD	B0928	**2E-06**	<1	<1
3	RD	B0929	9E-07	<1	<1
3	RD	B0930	4E-08	<1	<1
3	RD	B1028	**7E-06**	1E+01	**7E+00**
3	RD	B1029	**3E-04**	8E+00	**5E+00**
3	RD	B1030	1E-07	<1	<1
3	RD	B1128	**1E-05**	2E+00	<1
3	RD	B1129	**1E-04**	1E+01	**7E+00**
3	RD	B1130	**1E-04**	1E+01	**6E+00**
3	RD	B1131	**3E-04**	1E+01	**4E+00**
3	RD	B1228	**3E-06**	2E+00	<1
3	RD	B1229	**3E-06**	2E+00	<1
3	RD	B1230	**2E-05**	3E+00	**2E+00**

TABLE 3-9: INCREMENTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SUBSURFACE SOIL (0 TO 10 FEET BGS) (CONTINUED)
Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
3	RD	B1231	**1E-05**	2E+00	**2E+00**
3	RD	B1328	**7E-06**	1E+01	**9E+00**
3	RD	B1329	**6E-06**	2E+00	<1
3	RD	B1330	**3E-03**	1E+01	**8E+00**
3	RD	B1331	**1E-03**	6E+00	**3E+00**
5	RD	B1427	--	--	--
5	RD	B1527	--	<1	<1
5	RD	B1628	--	<1	<1
5	RD	B1632	**2E-06**	<1	<1
5	RD	B1727	--	<1	<1
5	RD	B1728	--	<1	<1
5	RD	B1729	--	<1	<1
5	RD	B1928	--	<1	<1
5	RD	B1930	--	<1	<1
5	RD	B1931	--	<1	<1
5	RD	B2028	1E-07	<1	<1
5	RD	B2030	--	<1	<1
5	RD	B2032	--	<1	<1
5	RD	B2127	**2E-06**	<1	<1
5	RD	B2128	**3E-06**	<1	<1
5	RD	B2129	4E-08	<1	<1
5	RD	B2130	--	<1	<1
5	RD	B2131	--	<1	<1
5	RD	B2132	--	<1	<1
5	RD	B2228	**4E-06**	<1	<1
5	RD	B2230	3E-08	<1	<1
5	RD	B2232	1E-09	<1	<1
5	RD	B2332	--	<1	<1
6	RD	B1626	**7E-06**	2E+00	<1
6	RD	B1723	--	<1	<1
6	RD	B1826	1E-08	<1	<1
6	RD	B2026	**2E-06**	<1	<1
6	RD	B2224	**6E-06**	--	--
6	RD	B2225	1E-07	<1	<1
6	RD	B2226	**3E-06**	<1	<1
6	RD	B2325	4E-08	<1	<1
6	RD	B2326	--	<1	<1
6	RD	B2419	--	<1	<1
6	RD	B2425	2E-07	2E+00	<1
6	RD	B2526	1E-08	<1	<1
6	RD	B1424	9E-07	<1	<1
6	RD	B1425	**2E-06**	<1	<1
6	RD	B1426	**8E-06**	4E+00	**2E+00**
6	RD	B1523	--	<1	<1
6	RD	B1526	--	<1	<1
6	RD	B1622	--	<1	<1
6	RD	B1623	--	<1	<1
7	MU	B2635	7E-07	3E+00	**3E+00**
7	MU	B2727	--	6E+00	**3E+00**

TABLE 3-9: INCREMENTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SUBSURFACE SOIL (0 TO 10 FEET BGS) (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
7	MU	B2735	**4E-04**	4E+00	**3E+00**
7	MU	B2835	6E-07	<1	<1
7	MU	B3127	--	<1	<1
7	MU	B3128	--	2E+00	**2E+00**
7	MU	B3228	7E-09	4E+00	**3E+00**
7	MU	B3229	1E-06	2E+00	**2E+00**
7	MU	B3328	--	<1	<1
7	MU	B3433	4E-08	<1	<1
7	MU	B3434	--	<1	<1
8	MU	B2623	5E-07	<1	<1
8	MU	B2624	1E-06	<1	<1
8	MU	B2625	--	<1	<1
8	MU	B2722	1E-08	3E+00	**2E+00**
8	MU	B2723	**1E-05**	<1	<1
8	MU	B2724	**3E-05**	<1	<1
8	MU	B2725	4E-07	<1	<1
8	MU	B2726	3E-08	<1	<1
8	MU	B2823	**6E-05**	2E+00	**2E+00**
8	MU	B2824	**1E-05**	<1	<1
8	MU	B2826	--	--	--
8	MU	B2922	2E-08	<1	<1
8	MU	B2923	**2E-04**	1E+01	**1E+01**
8	MU	B2924	**7E-06**	<1	<1
8	MU	B2926	1E-06	3E+00	**2E+00**
8	MU	B3023	9E-09	<1	<1
8	MU	B3024	2E-08	<1	<1
8	MU	B3026	--	--	--
8	MU	B3124	1E-06	--	--
8	MU	B3126	1E-07	2E+00	**2E+00**
8	MU	B3324	--	--	--
8	MU	B3326	1E-08	<1	<1
8	MU	B3422	**3E-06**	<1	<1
8	MU	B3423	1E-07	<1	<1
8	MU	B3425	--	2E+00	**2E+00**
8	MU	B3426	1E-07	<1	<1
8	MU	B3522	--	<1	<1
8	MU	B3622	6E-07	2E+00	**2E+00**
8	MU	B3623	2E-07	<1	<1
9	MU	B2716	--	<1	<1
9	MU	B2818	**2E-06**	--	--
9	MU	B2918	--	<1	<1
9	MU	B2921	1E-08	<1	<1
9	MU	B3117	--	2E+00	**2E+00**
9	MU	B3118	3E-07	2E+00	**2E+00**
9	MU	B3215	**6E-06**	<1	<1
9	MU	B3217	--	2E+00	**2E+00**
9	MU	B3218	--	2E+00	**2E+00**
9	MU	B3220	--	<1	<1
9	MU	B3315	**4E-06**	<1	<1

TABLE 3-9: INCREMENTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SUBSURFACE SOIL (0 TO 10 FEET BGS) (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
9	MU	B3316	9E-07	<1	<1
9	MU	B3415	**3E-06**	6E+00	**3E+00**
9	MU	B3418	--	<1	<1
9	MU	B3421	2E-07	2E+00	**2E+00**
9	MU	B3515	**2E-06**	<1	<1
9	MU	B3516	--	<1	<1
9	MU	B3520	--	<1	<1
9	MU	B3615	--	<1	<1
12	MU	B3715	4E-07	<1	<1
12	MU	B3718	8E-09	2E+00	**2E+00**
12	MU	B3815	1E-06	5E+00	**4E+00**
12	MU	B3816	3E-09	2E+00	**2E+00**
12	MU	B3915	**8E-06**	<1	<1
12	MU	B3916	3E-10	<1	<1
12	MU	B3917	**6E-06**	<1	<1
12	MU	B3919	**3E-06**	--	--
12	MU	B3920	6E-07	--	--
12	MU	B4015	1E-06	2E+00	**2E+00**
12	MU	B4016	**2E-06**	<1	<1
12	MU	B4017	**2E-05**	2E+00	**2E+00**
12	MU	B4018	4E-07	<1	<1
12	MU	B4019	1E-06	3E+00	**3E+00**
12	MU	B4020	7E-08	3E+00	**3E+00**
12	MU	B4115	5E-07	<1	<1
12	MU	B4116	--	3E+00	**3E+00**
12	MU	B4117	6E-07	<1	<1
12	MU	B4215	1E-06	<1	<1
12	MU	B4217	--	2E+00	**2E+00**
12	MU	B4218	1E-06	<1	<1
12	MU	B4219	1E-07	2E+00	**2E+00**
12	MU	B4220	--	2E+00	**2E+00**
12	MU	B4315	8E-07	4E+00	**3E+00**
12	MU	B4320	--	2E+00	**2E+00**
12	MU	B4415	--	<1	<1
12	MU	B4418	4E-07	<1	<1
12	MU	B4419	8E-07	<1	<1
12	MU	B4420	5E-07	<1	<1
12	MU	B4421	7E-07	<1	<1
12	MU	B4515	1E-07	<1	<1
12	MU	B4517	--	3E+00	**2E+00**
12	MU	B4518	5E-07	<1	<1
12	MU	B4519	4E-07	<1	<1
12	MU	B4520	**4E-06**	<1	<1
12	MU	B4521	3E-07	<1	<1
12	MU	B4615	--	3E+00	**3E+00**
12	MU	B4616	--	<1	<1
12	MU	B4617	2E-08	3E+00	**2E+00**
12	MU	B4620	4E-08	<1	<1
12	MU	B4621	8E-07	<1	<1

TABLE 3-9: INCREMENTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SUBSURFACE SOIL (0 TO 10 FEET BGS) (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
15	MU	B4716	**4E-05**	5E+00	**2E+00**
15	MU	B4717	--	<1	<1
15	MU	B4816	5E-08	<1	<1
15	MU	B4817	--	<1	<1
15	MU	B4818	--	<1	<1
15	MU	B4819	--	<1	<1
15	MU	B4916	--	<1	<1
15	MU	B4917	5E-08	<1	<1
16	E/C	AX04	**1E-04**	<1	<1
16	E/C	AY03	**6E-05**	<1	<1
16	E/C	AY04	**1E-05**	<1	<1

Notes: Values shown in boldface exceed the threshold level of 1E-06 for cancer risks and 1.0 for segregated noncancer hazards.

-- Not applicable
bgs Below ground surface
E/C Educational/cultural (industrial exposure scenario)
MU Mixed use (residential exposure scenario)
RD Research and development (residential exposure scenario)
RME Reasonable maximum exposure

TABLE 3-10: INCREMENTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SUBSURFACE SOIL (0 TO 10 FEET BGS), CONSTRUCTION WORKER

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
1	MU	AF15	1E-07	--	--
1	MU	AF16	--	<1	<1
2	RD	AF14	5E-07	<1	<1
2	RD	AG12	9E-09	<1	<1
2	RD	AG13	9E-08	<1	<1
2	RD	AG14	6E-08	<1	<1
2	RD	AH13	2E-09	<1	<1
2	RD	AI12	2E-07	<1	<1
3	RD	AH10	1E-07	<1	<1
3	RD	AI10	6E-07	<1	<1
3	RD	AI11	**5E-06**	<1	<1
5	RD	AJ10	**2E-05**	<1	<1
5	RD	AJ11	**3E-05**	<1	<1
5	RD	AK10	--	<1	<1
5	RD	AK11	1E-07	<1	<1
5	RD	AL10	2E-07	<1	<1
5	RD	AL11	--	<1	<1
5	RD	AM10	2E-07	<1	<1
5	RD	AM11	4E-11	<1	<1
6	RD	AJ09	3E-07	<1	<1
6	RD	AK08	--	<1	<1
6	RD	AK09	2E-07	<1	<1
6	RD	AL09	1E-07	<1	<1
6	RD	AM07	--	<1	<1
6	RD	AM08	3E-07	--	--
6	RD	AM09	2E-07	<1	<1
7	MU	AN12	**7E-06**	<1	<1
7	MU	AO12	4E-08	<1	<1
7	MU	AP10	4E-08	<1	<1
7	MU	AQ11	8E-10	<1	<1
7	MU	AQ12	--	<1	<1
8	MU	AN08	8E-07	<1	<1
8	MU	AN09	7E-09	<1	<1
8	MU	AO08	**6E-06**	<1	<1
8	MU	AO09	8E-08	<1	<1
8	MU	AP08	7E-08	--	--
8	MU	AP09	3E-09	<1	<1
8	MU	AQ08	2E-07	<1	<1
8	MU	AQ09	2E-09	<1	<1
9	MU	AO06	1E-07	<1	<1
9	MU	AO07	2E-10	<1	<1
9	MU	AP06	6E-08	<1	<1
9	MU	AP07	--	<1	<1
9	MU	AQ06	--	<1	<1
9	MU	AQ07	7E-10	<1	<1
12	MU	AR06	3E-07	<1	<1
12	MU	AR07	2E-07	--	--
12	MU	AS06	6E-07	<1	<1
12	MU	AS07	9E-08	<1	<1
12	MU	AT06	3E-08	<1	<1
12	MU	AT07	4E-08	<1	<1
15	MU	AU06	**2E-06**	<1	<1

TABLE 3-10: INCREMENTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SUBSURFACE SOIL (0 TO 10 FEET BGS), CONSTRUCTION WORKER (CONTINUED)
Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME Hazard Index	RME Segregated Hazard Index
15	MU	AU07	5E-08	<1	<1
15	MU	AV06	--	<1	<1
16	E/C	AX04	**4E-05**	2E+00	<1
16	E/C	AY03	**2E-05**	<1	<1
16	E/C	AY04	**4E-06**	<1	<1
BOS-1	OS	AE09	1E-07	<1	<1
BOS-1	OS	AE10	6E-07	<1	<1
BOS-1	OS	AE11	--	<1	<1
BOS-1	OS	AE13	4E-08	<1	<1
BOS-1	OS	AE14	2E-07	<1	<1
BOS-1	OS	AF09	**6E-06**	2E+00	<1
BOS-1	OS	AF10	**3E-06**	<1	<1
BOS-1	OS	AF11	2E-07	<1	<1
BOS-1	OS	AF12	1E-07	<1	<1
BOS-1	OS	AF13	4E-07	<1	<1
BOS-1	OS	AG09	5E-07	<1	<1
BOS-1	OS	AG10	4E-07	<1	<1
BOS-1	OS	AG11	5E-07	<1	<1
BOS-1	OS	AH08	3E-07	<1	<1
BOS-1	OS	AH09	7E-07	<1	<1
BOS-1	OS	AI08	9E-07	<1	<1
BOS-1	OS	AI09	3E-07	<1	<1
BOS-1	OS	AJ06	2E-07	<1	<1
BOS-1	OS	AJ07	3E-07	<1	<1
BOS-1	OS	AJ08	**2E-06**	4E+00	**3E+00**
BOS-2	OS	AK06	**7E-06**	<1	<1
BOS-2	OS	AK07	2E-11	<1	<1
BOS-2	OS	AL06	--	<1	<1
BOS-2	OS	AL07	--	<1	<1
BOS-2	OS	AM05	4E-08	<1	<1
BOS-2	OS	AM06	--	<1	<1
BOS-2	OS	AN05	5E-07	<1	<1
BOS-2	OS	AN06	1E-08	<1	<1
BOS-2	OS	AO05	3E-07	<1	<1
BOS-2	OS	AP05	3E-07	<1	<1
BOS-2	OS	AQ05	5E-07	<1	<1
BOS-2	OS	AR05	3E-07	<1	<1
BOS-2	OS	AS05	4E-07	<1	<1
BOS-2	OS	AT05	4E-08	<1	<1
BOS-3	OS	AU05	**2E-06**	3E+00	**2E+00**
BOS-3	OS	AV04	5E-08	<1	<1
BOS-3	OS	AV05	1E-07	<1	<1
BOS-3	OS	AW03	**2E-05**	3E+00	<1

TABLE 3-10: INCREMENTAL RISK: SUMMARY OF CANCER RISKS AND HAZARD INDICES BY PLANNED REUSE, SUBSURFACE SOIL (0 TO 10 FEET BGS), CONSTRUCTION WORKER (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Notes:	Values shown in boldface exceed the threshold level of 1E-06 for cancer risks and 1.0 for segregated noncancer hazards.
--	Not applicable
bgs	Below ground surface
E/C	Educational/cultural (industrial exposure scenario)
MU	Mixed use (residential exposure scenario)
OS	Open space (recreational exposure scenario)
RD	Research and development (residential exposure scenario)
RME	Reasonable maximum exposure

TABLE 3-13: INCREMENTAL RISK: RISK CHARACTERIZATION ANALYSIS FOR SUBSURFACE SOIL (0 TO 10 FEET BGS), CONSTRUCTION WORKER SCENARIO

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	Total RME Cancer Risk	Total RME HI	RME Segregated HI		COC	Basis for COC	Range of Detected Concentrations	RME EPC	DF	Chemical-Specific Cancer Risk	Chemical-Specific HI
3	RD	AI11	5E-06	<1	<1	Metal	ARSENIC	C	2.6 - 13.3	7.36E+00	10/11	4.54E-06	<1
5	RD	AJ10	2E-05	<1	<1	Metal	ARSENIC	C	3.6 - 123.95	3.25E+01	13/13	2.01E-05	<1
5	RD	AJ11	3E-05	<1	<1	Metal	ARSENIC	C	4.9 - 50	5.00E+01	2/2	3.08E-05	<1
7	MU	AN12	7E-06	<1	<1	Metal	ARSENIC	C	2.4 - 15.1	1.05E+01	5/5	6.50E-06	<1
8	MU	AO08	6E-06	<1	<1	Metal	ARSENIC	C	1.2 - 11.7	7.11E+00	16/25	4.38E-06	<1
						VOC	TRICHLOROETHENE	C	0.005 - 230	2.30E+02	124/145	1.52E-06	<1
15	MU	AU06	2E-06	<1	<1	PAH	BENZO(A)PYRENE	C	0.88 - 0.88	8.80E-01	1/32	1.36E-06	--
16	E/C	AX04	4E-05	2E+00	<1	Metal	ARSENIC	C	0.8 - 55.2	5.52E+01	4/7	3.40E-05	<1
						PAH	BENZO(A)PYRENE	C	0.042 - 0.8	8.00E-01	4/7	1.24E-06	--
16	E/C	AY03	2E-05	<1	<1	Metal	ARSENIC	C	3.475 - 54.1	2.15E+01	13/17	1.33E-05	<1
						PAH	BENZO(A)PYRENE	C	0.0175 - 2.1	2.04E+00	13/17	3.16E-06	--
16	E/C	AY04	4E-06	<1	<1	Metal	ARSENIC	C	3.3 - 12.4	6.08E+00	6/11	3.75E-06	<1
BOS-1	OS	AE09	1E-07	<1	<1	Metal	LEAD	NC	126 - 4300	3.75E+03	4/4	--	--
BOS-1	OS	AE10	6E-07	<1	<1	Metal	LEAD	NC	1140 - 6160	5.55E+03	5/5	--	--
BOS-1	OS	AE14	2E-07	<1	<1	Metal	LEAD	NC	35 - 2210	2.21E+03	5/5	--	--
BOS-1	OS	AF09	6E-06	2E+00	<1	Metal	LEAD	NC	93 - 2160	1.19E+03	14/14	--	--
						PAH	BENZO(A)PYRENE	C	0.012 - 2.8	2.13E+00	7/14	3.30E-06	--
BOS-1	OS	AF10	3E-06	<1	<1	Metal	LEAD	NC	13 - 4790	2.05E+03	23/23	--	--
						PAH	BENZO(A)PYRENE	C	0.018 - 1.4	1.40E+00	15/21	2.17E-06	--
BOS-1	OS	AI09	3E-07	<1	<1	Metal	LEAD	NC	10.3 - 8540	8.44E+02	35/35	--	--
BOS-1	OS	AJ08	2E-06	4E+00	3E+00	Pest/PCB	AROCLOR-1260	C,NC	0.012 - 50	6.57E+00	10/21	1.78E-06	3.11E+00
BOS-2	OS	AK06	7E-06	<1	<1	Metal	ARSENIC	C	0.92 - 11.7	1.17E+01	5/9	7.21E-06	<1
BOS-2	OS	AQ05	5E-07	<1	<1	Metal	LEAD	NC	1.5 - 3900	1.09E+03	11/13	--	--
BOS-3	OS	AU05	2E-06	3E+00	2E+00	Pest/PCB	AROCLOR-1260	NC	0.073 - 3.1	3.10E+00	3/11	8.39E-07	1.47E+00
BOS-3	OS	AW03	2E-05	3E+00	<1	Metal	ARSENIC	C	7.7 - 28	2.80E+01	2/2	1.73E-05	<1
						Pest/PCB	AROCLOR-1260	NC	0.2 - 2.7	2.70E+00	2/2	7.31E-07	1.28E+00

Notes: All concentrations shown in mg/kg.

--	Not applicable or chemical is not a COC for this endpoint
bgs	Below ground surface
C	Cancer effect
COC	Chemical of concern
DF	Detection frequency
E/C	Educational/cultural (industrial exposure scenario)
EPC	Exposure point concentration
HI	Hazard index
HPAL	Hunters Point ambient level
mg/kg	Milligram per kilogram
MU	Mixed use (residential exposure scenario)
NC	Noncancer effect
PAH	Polynuclear aromatic hydrocarbon
Pest	Pesticide
PCB	Polychlorinated biphenyl
OS	Open space (recreational exposure scenario)
RD	Research and development (residential exposure scenario)
RME	Reasonable maximum exposure

TABLE 3-14: RISK CHARACTERIZATION ANALYSIS FOR A-AQUIFER GROUNDWATER BASED ON PLANNED REUSE

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Exposure Area	Total RME Cancer Risk	Total RME HI	RME Segregated HI	Exposure Pathway	Source Aquifer for Exposure Pathway	Total RME Cancer Risk for Exposure Pathway	Total RME HI for Exposure Pathway		COC	Basis for COC	DF	RME Concentration (µg/L)	Chemical-Specific Cancer Risk	Percent Contribution to Total RME Cancer Risk for Exposure Pathway	Chemical-Specific HI	Percent Contribution to Total RME HI for Exposure Pathway
8, 9	MU	IR-10A Plume	6.04E-03	2.55E+00	2.03E+00	Vapor Intrusion	A	6.04E-03	2.55E+00	VOC	CHLOROFORM	C	12 / 61	4.3E+00	6.2E-06	0.1%	<1	--
											TRICHLOROETHENE	C	51 / 61	1.9E+02	6.4E-05	1.1%	<1	--
											VINYL CHLORIDE	C	8 / 61	1.7E+02	6.0E-03	98.8%	1.9E+00	73.7%
8, 12	MU	IR-25 Plume	9.87E-02	6.89E+02	3.31E+02	Vapor Intrusion	A	9.87E-02	6.89E+02	VOC	1,2,4-TRICHLOROBENZENE	NC	17 / 278	1.1E+02	--	--	1.6E+00	0.2%
											1,2,4-TRIMETHYLBENZENE	NC	7 / 37	9.1E+01	--	--	3.6E+00	0.5%
											1,2-DICHLOROBENZENE	NC	72 / 288	1.1E+04	--	--	4.4E+00	0.6%
											1,2-DICHLOROETHANE	C, NC	61 / 309	2.5E+04	1.1E-02	10.9%	2.0E+02	29.7%
											1,2-DICHLOROETHENE (TOTAL)	NC	28 / 89	8.2E+03	--	--	3.9E+01	5.7%
											1,2-DICHLOROPROPANE	C, NC	16 / 309	2.2E+02	2.0E-04	0.2%	6.5E+00	0.9%
											1,3,5-TRIMETHYLBENZENE	NC	4 / 37	2.2E+01	--	--	1.2E+00	0.2%
											1,4-DICHLOROBENZENE	C	58 / 290	3.7E+03	1.7E-03	1.8%	<1	--
											2-METHYLNAPHTHALENE[a]	NC	23 / 141	9.2E+02	--	--	1.3E+00	3.7%
											BENZENE	C	78 / 314	9.3E+01	2.5E-04	0.3%	<1	--
											BROMODICHLOROMETHANE	C	3 / 309	1.3E+02	1.3E-04	0.1%	<1	--
											CHLOROBENZENE	NC	38 / 306	1.5E+03	--	--	3.9E+00	0.6%
											CHLOROETHANE	C	11 / 309	5.1E+01	7.8E-06	0.0%	<1	--
											CHLOROFORM	C	18 / 309	1.3E+01	1.9E-05	0.0%	<1	--
											CIS-1,2-DICHLOROETHENE	NC	104 / 246	1.5E+04	--	--	7.1E+01	10.3%
											MERCURY	NC	13 / 130	3.6E+00	--	--	5.2E+00	0.8%
											METHYLENE CHLORIDE	C	10 / 309	2.0E+02	7.4E-06	0.0%	<1	--
											NAPHTHALENE	C, NC	39 / 178	2.0E+02	5.7E-05	0.1%	1.3E+00	0.2%
											TETRACHLOROETHENE	C, NC	65 / 309	1.4E+04	2.6E-02	26.3%	3.0E+02	43.6%
											TRANS-1,2-DICHLOROETHENE	NC	51 / 246	8.3E+02	--	--	4.5E+00	0.7%
											TRICHLOROETHENE	C, NC	115 / 309	3.6E+03	1.2E-03	1.3%	2.5E+00	0.4%
											TRICHLOROFLUOROMETHANE	NC	17 / 211	3.0E+03	--	--	1.7E+01	2.5%
											VINYL CHLORIDE	C, NC	97 / 309	1.7E+03	5.8E-02	59.2%	1.8E+01	2.7%
5	RD	B1528	1.86E-06	2.16E-02	2.16E-02	Vapor Intrusion	A	1.86E-06	2.16E-02	VOC	TETRACHLOROETHENE	C	1 / 3	1.0E+00	1.9E-06	100.0%	<1	--
12	MU	B4219	--	2.94E+00	2.94E+00	Vapor Intrusion	A	--	2.94E+00	VOC	MERCURY	NC	2 / 3	2.0E+00	--	--	2.9E+00	100.0%
12	MU	B4516	--	4.32E+00	4.19E+00	Vapor Intrusion	A	--	4.32E+00	VOC	DICHLORODIFLUOROMETHANE	NC	9 / 12	5.9E+01	--	--	4.1E+00	95.9%
15	MU	B5117	--	1.35E+00	1.34E+00	Vapor Intrusion	A	--	1.35E+00	VOC	MERCURY	NC	3 / 4	9.1E-01	--	--	1.3E+00	99.1%
16	E/C	AY04	3.41E-06	3.80E-01	3.68E-01	Vapor Intrusion	A	3.41E-06	3.80E-01	VOC	CHLOROFORM	C	3 / 6	4.0E+00	3.4E-06	100.0%	<1	--

Notes:

All concentrations shown in micrograms per liter (µg/L).

Risk results shown are based on inhalation exposure to A-aquifer groundwater via vapor intrusion to indoor air.

Unless noted,chemicals listed are based on results for the RME scenario.

a	Chemical is a COC based on the MAX scenario (see Section A5.1.2). Results shown are for the MAX scenario.
--	Not applicable or chemical is not a COC for this endpoint
C	Cancer effect
COC	Chemical of concern
DF	Detection frequency
E/C	Educational/cultural (industrial exposure scenario)
HI	Hazard index
IR	Installation restoration
MAX	Maximum concentration exposure
MU	Mixed use (residential exposure scenario)
NC	Noncancer effect
RD	Research and development (residential exposure scenario)
RME	Reasonable maximum exposure scenario
VOC	Volatile organic compound

TABLE 3-15: RISK CHARACTERIZATION ANALYSIS FOR B-AQUIFER GROUNDWATER WITH POTENTIAL HYDRAULIC COMMUNICATION
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse[a]	Exposure Area	Total RME Cancer Risk	Total RME HI	RME Segregated HI	Exposure Pathway	Source Aquifer for Exposure Pathway	Total RME Cancer Risk for Exposure Pathway	Total RME HI for Exposure Pathway		COC	Basis for COC	DF	RME Concentration (μg/L)	Chemical-Specific Cancer Risk	Percent Contribution to Total RME Cancer Risk for Exposure Pathway	Chemical-Specific HI	Percent Contribution to Total RME HI for Exposure Pathway
2	RD	B0238	8.90E-04	1.43E+00	5.75E-01	Domestic Use	B	8.90E-04	1.43E+00	Metal	ARSENIC	C	1 / 5	6.3E+00	8.9E-04	100.0%	<1	--
BOS-1	OS	B0139	1.40E-03	8.13E+00	3.74E+00	Domestic Use	B	1.40E-03	8.13E+00	Metal	ANTIMONY[b]	NC	2 / 14	2.1E+01	--	--	1.5E+00	17.8%
											ARSENIC[b]	C	4 / 13	9.5E+00	1.3E-03	95.8%	<1	--
											MANGANESE[b]	NC	14 / 14	1.4E+03	--	--	1.6E+00	19.1%
											THALLIUM[b]	NC	3 / 12	8.4E+00	--	--	3.5E+00	42.7%
										SVOC	PENTACHLOROPHENOL[b]	C	1 / 10	2.4E+01	4.3E-05	3.1%	<1	--
										VOC	1,4-DICHLOROBENZENE[b]	C	3 / 14	4.1E-01	1.4E-06	0.10%	<1	--
											BENZENE[b]	C	1 / 14	1.0E+00	9.0E-06	0.65%	<1	--
											CHLOROETHANE[b]	C	1 / 14	1.3E+01	2.8E-06	0.20%	<1	--
											TRICHLOROETHENE[b]	C	1 / 14	2.0E+00	1.4E-06	0.10%	<1	--
BOS-1	OS	B0237	--	3.78E+00	2.75E+00	Domestic Use	B	--	3.78E+00	Metal	MANGANESE[b]	NC	3 / 3	2.4E+03	--	--	2.8E+00	72.7%

Notes: All concentrations shown in micrograms per liter (μg/L).
Risk results shown are based on based on residential exposure to B-aquifer groundater from domestic use.
Risk results are based on B-aquifer data combined with A-aquifer data to address potential hydraulic communication between the A- and B-aquifers. For some exposure points, both A- and B-aquifer data may not be available. In these cases, the summary statistics shown are based on the available data.

a The risk chracterization analysis for domestic use of groundwater in the B-aquifer is based on risk results parcel-wide, regardless of planned reuse.
b Chemical is a COC based on A-aquifer data and potential hydraulic communication with the B-aquifer; B-aquifer data are not available for this chemical at this exposure area.
-- Not applicable or chemical is not a COC for this endpoint
C Cancer effect
COC Chemical of concern
DF Detection frequency
HI Hazard index
NC Noncancer effect
OS Open space (recreational exposure scenario)
RD Research and development (residential exposure scenario)
RME Reasonable maximum exposure
SVOC Semivolatile organic compound
VOC Volatile organic compound

TABLE 3-16: RISK CHARACTERIZATION ANALYSIS FOR A-AQUIFER GROUNDWATER, CONSTRUCTION WORKER EXPOSURE SCENARIO
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Exposure Area	Total RME Cancer Risk	Total RME HI	RME Segregated HI	Exposure Pathway	Source Aquifer for Exposure Pathway	Total RME Cancer Risk for Exposure Pathway	Total RME HI for Exposure Pathway		COC	Basis for COC	DF	RME Concentration (µg/L)	Chemical-Specific Cancer Risk	Percent Contribution to Total RME Cancer Risk for Exposure Pathway	Chemical-Specific HI	Percent Contribution to Total RME HI for Exposure Pathway
8, 9	MU	IR-10A Plume	2.43E-05	6.50E-01	3.50E-01	Trench Vapor Inhalation	A	2.21E-05	5.02E-01	VOC	TRICHLOROETHENE[a]	C	51 / 61	6.1E+02	1.4E-06	6.0%	<1	--
											VINYL CHLORIDE	C	8 / 61	1.7E+02	2.2E-05	97.4%	<1	--
						Trench Dermal	A	2.16E-06	1.48E-01	VOC	TRICHLOROETHENE[a]	C	51 / 61	6.1E+02	2.5E-07	10.8%	--	--
											VINYL CHLORIDE	C	8 / 61	1.7E+02	1.9E-06	87.6%	<1	--
8, 12	MU	IR-25 Plume	2.72E-03	5.96E+02	4.43E+02	Trench Vapor	A	1.18E-03	5.58E+02	VOC	1,2,4-TRICHLOROBENZENE	NC	17 / 278	1.1E+02	--	--	1.8E+00	0.3%
											1,2,4-TRIMETHYLBENZENE	NC	7 / 37	9.1E+01	--	--	1.3E+00	0.2%
											1,2-DICHLOROBENZENE	NC	72 / 288	1.1E+04	--	--	4.1E+00	0.7%
											1,2-DICHLOROETHANE	C, NC	61 / 309	2.5E+04	8.0E-04	68.3%	4.4E+02	79.2%
											1,2-DICHLOROETHENE (TOTAL)	NC	28 / 89	8.2E+03	--	--	2.1E+01	3.8%
											1,2-DICHLOROPROPANE	C, NC	16 / 309	2.2E+02	5.1E-06	0.4%	4.8E+00	0.9%
											1,4-DICHLOROBENZENE	C	58 / 290	3.7E+03	4.5E-05	3.8%	<1	--
											2-METHYLNAPHTHALENE	NC	23 / 141	4.9E+02	--	--	2.4E+00	0.4%
											BENZENE	C	78 / 314	9.3E+01	3.9E-06	0.3%	<1	--
											BROMODICHLOROMETHANE	C	3 / 309	1.3E+02	4.8E-06	0.4%	<1	--
											CHLOROBENZENE	NC	38 / 306	1.5E+03	--	--	2.2E+00	0.4%
											CHLOROFORM[a]	C	18 / 309	3.9E+01	1.1E-06	0.0%	<1	--
											CIS-1,2-DICHLOROETHENE	NC	104 / 246	1.5E+04	--	--	3.9E+01	6.9%
											MERCURY[a]	NC	13 / 130	8.0E+00	--	--	1.7E+00	0.1%
											NAPHTHALENE	C, NC	39 / 178	2.0E+02	7.2E-06	0.6%	4.9E+00	0.9%
											TETRACHLOROETHENE	C, NC	65 / 309	1.4E+04	8.4E-05	7.2%	2.8E+01	5.0%
											TRANS-1,2-DICHLOROETHENE	NC	51 / 246	8.3E+02	--	--	1.1E+00	0.2%
											TRICHLOROETHENE	C	115 / 309	3.6E+03	8.1E-06	0.7%	<1	--
											VINYL CHLORIDE	C, NC	97 / 309	1.7E+03	2.1E-04	17.9%	1.9E+00	0.3%
						Trench Dermal	A	1.54E-03	3.82E+01	SVOC	2,4-DIMETHYLPHENOL	NC	9 / 118	1.6E+04	--	--	1.6E+00	4.3%
											2,4-DINITROTOLUENE	C, NC	1 / 129	4.9E+03	2.7E-05	1.8%	1.4E+00	3.7%
											4-METHYLPHENOL	NC	8 / 118	9.1E+03	--	--	2.6E+00	6.8%
											BENZO(A)ANTHRACENE	C	2 / 144	3.1E+00	4.6E-06	0.3%	--	--
											BENZO(A)PYRENE	C	1 / 144	2.1E-01	4.7E-06	0.3%	--	--
											CHRYSENE	C	2 / 146	2.0E+02	3.0E-05	1.9%	--	--
											PENTACHLOROPHENOL	C, NC	2 / 119	6.1E+03	7.6E-04	49.1%	1.5E+01	38.5%
										VOC	1,2,4-TRICHLOROBENZENE	NC	17 / 278	1.1E+02	6.8E-08	0.0%	<1	--
											1,2,4-TRIMETHYLBENZENE	NC	7 / 37	9.1E+01	--	--	<1	--
											1,2-DICHLOROBENZENE	NC	72 / 288	1.1E+04	--	--	<1	--
											1,2-DICHLOROETHANE	C	61 / 309	2.5E+04	2.5E-05	1.6%	<1	--
											1,2-DICHLOROETHENE (TOTAL)	NC	28 / 89	8.2E+03	--	--	1.2E+00	3.1%
											1,2-DICHLOROPROPANE	C	16 / 309	2.2E+02	3.1E-07	0.0%	<1	--
											1,4-DICHLOROBENZENE	C	58 / 290	3.7E+03	9.9E-06	0.6%	<1	--
											2-METHYLNAPHTHALENE	NC	23 / 141	4.9E+02	--	--	1.1E+00	2.8%
											BENZENE	C	78 / 314	9.3E+01	3.7E-07	0.0%	<1	--
											BROMODICHLOROMETHANE	C	3 / 309	1.3E+02	2.1E-07	0.0%	<1	--
											CHLOROBENZENE	NC	38 / 306	1.5E+03	--	--	<1	--
											CHLOROFORM[a]	C	18 / 309	3.9E+01	2.2E-08	0.0%	<1	--
											CIS-1,2-DICHLOROETHENE	NC	104 / 246	1.5E+04	--	--	2.1E+00	5.6%
											MERCURY[a]	NC	13 / 130	8.0E+00	--	--	<1	--
											NAPHTHALENE	C	39 / 178	2.0E+02	3.0E-06	0.2%	<1	--

TABLE 3-16: RISK CHARACTERIZATION ANALYSIS FOR A-AQUIFER GROUNDWATER, CONSTRUCTION WORKER EXPOSURE SCENARIO (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Exposure Area	Total RME Cancer Risk	Total RME HI	RME Segregated HI	Exposure Pathway	Source Aquifer for Exposure Pathway	Total RME Cancer Risk for Exposure Pathway	Total RME HI for Exposure Pathway		COC	Basis for COC	DF	RME Concentration (µg/L)	Chemical-Specific Cancer Risk	Percent Contribution to Total RME Cancer Risk for Exposure Pathway	Chemical-Specific HI	Percent Contribution to Total RME HI for Exposure Pathway
8, 12	MU	IR-25 Plume (continued)	2.72E-03	5.96E+02	4.43E+02	Trench Dermal	A	1.54E-03	3.82E+01	VOC	TETRACHLOROETHENE	C, NC	65 / 309	1.4E+04	6.6E-04	42.7%	8.5E+00	22.3%
											TRANS-1,2-DICHLOROETHENE	NC	51 / 246	8.3E+02	--	--	<1	--
											TRICHLOROETHENE	C	115 / 309	3.6E+03	1.5E-06	0.1%	--	--
											VINYL CHLORIDE	C	97 / 309	1.7E+03	1.9E-05	1.2%	<1	--
3	RD	AH11	1.28E-06	1.45E-01	5.17E-02	Trench Vapor Inhalation	A	1.2E-09	4.9E-02	Metal	ARSENIC	C	8 / 11	5.11E+01	--	--	--	--
						Trench Dermal Contact	A	1.3E-06	9.6E-02	Metal	ARSENIC	C	8 / 11	5.11E+01	1.3E-06	100.0%	<1	--
BOS-1	OS	AF13	3.29E-06	1.38E-01	8.93E-02	Trench Vapor Inhalation	A	6.9E-08	1.8E-02	SVOC	PENTACHLOROPHENOL	C	1 / 13	2.40E+01	--	--	--	--
						Trench Dermal Contact	A	3.2E-06	1.2E-01	SVOC	PENTACHLOROPHENOL	C	1 / 13	2.40E+01	3.0E-06	92.3%	<1	--
BOS-3	OS	AU05	2.26E-07	1.74E+00	1.56E+00	Trench Vapor Inhalation	A	--	1.3E-01	SVOC	2,4,6-TRICHLOROPHENOL	NC	1 / 5	2.40E+01	--	--	--	--
						Trench Dermal Contact	A	2.3E-07	1.6E+00	SVOC	2,4,6-TRICHLOROPHENOL	NC	1 / 5	2.40E+01	1.6E-07	69.0%	1.6E+00	96.5%

Notes: All concentrations shown in micrograms per liter (µg/L).
Unless noted, chemicals listed are based on results for the RME scenario.

a	Chemical is a COC based on the MAX scenario (see Section A5.1.2). Results shown are for the MAX scenario.
--	Not applicable or chemical is not a COC for this endpoint
COC	Chemical of concern
C	Cancer effect
COC	Chemical of concern
DF	Detection frequency
HI	Hazard index
MAX	Maximum concentration exposure
MU	Mixed use (residential exposure scenario)
NC	Noncancer effect
OS	Open space (recreational exposure scenario)
RD	Research and development (residential exposure scenario)
RME	Reasonable maximum exposure
SVOC	Semivolatile organic compound
VOC	Volatile organic compound

Table 3-18: Remediation Goals for Chemicals of Concern in A-Aquifer Groundwater

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Exposure Scenario	Chemical of Concern	Associated Plume[a] or Grid Number	RBC	HGAL	Laboratory Practical Quantitation Limit	Chemical-specific ARAR[b]	Remediation Goal
Residential - Vapor Intrusion	1,2,4-Trichlorobenzene	IR-25	66	--	0.5	--	66
	1,2,4-Trimethylbenzene	IR-25	25	--	0.5	--	25
	1,2-Dichlorobenzene	IR-25	2,561	--	0.5	--	2,561
	1,2-Dichloroethane	IR-25	2.3	--	0.5	--	2.3
	1,2-Dichloroethene (total)	IR-25	209	--	0.5	--	209
	1,2-Dichloropropane	IR-25	1.1	--	1	--	1.1
	1,3,5-Trimethylbenzene	IR-25	19	--	1	--	19
	1,4-Dichlorobenzene	IR-25	2.1	--	1	--	2.1
	2-Methylnaphthalene[c]	IR-25	707	--	2	--	707
	Benzene	IR-25	0.4	--	0.5	--	0.5
	Bromodichloromethane	IR-25	1.0	--	1	--	1
	Chlorobenzene	IR-25	392	--	1	--	392
	Chloroethane	IR-25	6.5	--	1	--	6.5
	Chloroform	IR-10A, IR-25	0.7	--	1	--	1.0
	cis-1,2-Dichloroethene	IR-25	209	--	1	--	209
	Dichlorodifluoromethane	B4516	14	--	5	--	14
	Mercury	IR-25, B4219, B5117	0.68	0.60	0.1	--	0.68
	Methylene chloride	IR-25	27	--	1	--	27
	Naphthalene	IR-25	3.6	--	1	--	3.6
	Tetrachloroethene	IR-25, B1528	0.5	--	1	--	1
	trans-1,2-Dichloroethene	IR-25	182	--	1	--	182
	Trichloroethene	IR-10A, IR-25	2.9	--	1	--	2.9
	Trichlorofluoromethane	IR-25	176	--	1	--	176
	Vinyl chloride	IR-10A, IR-25	0.028	--	0.5	--	0.5
Industrial - Vapor Intrusion	Chloroform	AY04	1.2	--	1	--	1.2
Construction Worker - Trench Exposure	1,2,4-Trichlorobenzene	IR-25	55	--	0.5	--	55
	1,2,4-Trimethylbenzene	IR-25	72	--	0.5	--	72
	1,2-Dichlorobenzene	IR-25	2,215	--	0.5	--	2,215
	1,2-Dichloroethane	IR-25	30	--	0.5	--	30
	1,2-Dichloroethene (total)	IR-25	363	--	0.5	--	363
	1,2-Dichloropropane	IR-25	40	--	1	--	40
	1,4-Dichlorobenzene	IR-25	68	--	1	--	68
	2,4,6-Trichlorophenol	AU05	15	--	10	--	15
	2,4-Dimethylphenol	IR-25	9,801	--	10	--	9,801
	2,4-Dinitrotoluene	IR-25	179	--	10	--	179
	2-Methylnaphthalene	IR-25	140	--	2	--	140
	4-Methylphenol	IR-25	3,500	--	10	--	3,500
	Arsenic	AH11	40	27.34	1.0	--	40
	Benzene	IR-25	22	--	0.5	--	22
	Benzo(a)anthracene	IR-25	0.67	--	2	--	2
	Benzo(a)pyrene	IR-25	0.045	--	2	--	2
	Bromodichloromethane	IR-25	26	--	1	--	26
	Chlorobenzene	IR-25	594	--	1	--	594
	Chloroform[c]	IR-25	36	--	1	--	36
	Chrysene	IR-25	6.4	--	2	--	6.4
	cis-1,2-Dichloroethene	IR-25	363	--	1	--	363
	Mercury[c]	IR-25	4.68	0.60	0.1	--	4.68
	Naphthalene	IR-25	20	--	1	--	20
	Pentachlorophenol	IR-25, AF13	8.1	--	25	--	25
	Tetrachloroethene	IR-25	19	--	1	--	19
	trans-1,2-Dichloroethene	IR-25	721	--	1	--	721
	Trichloroethene	IR-10A, IR-25	374	--	1	--	374
	Vinyl chloride	IR-10A, IR-25	7.2	--	0.5	--	7.2
Environmental Evaluation	Mercury	IR-26	--	0.60	0.1	0.025	0.60

Notes: All concentrations shown in micrograms per liter (µg/L).

a The plumes listed (IR-10A, IR-25) are those defined for the risk assessment (see Attachment A4 of Appendix A).
b Chemical-specific ARARs are discussed in Section 4.2.
c Chemical is a COC based on the MAX scenario (see Section A5.1.2).
-- Not applicable or not available
ARAR Applicable or relevant and appropriate requirement
HGAL Hunters Point groundwater ambient level
IR Installation Restoration
MAX Maximum concentration exposure
RBC Exposure scenario-specific risk-based concentration

TABLE 3-19: REMEDIATION GOALS FOR CHEMICALS OF CONCERN IN B-AQUIFER GROUNDWATER
Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Exposure Scenario	Chemical of Concern	Associated Grid Number	RBC	HGAL	Laboratory Practical Quantitation Limit	Chemical-Specific ARAR[a]	Remediation Goal
Residential - Domestic Use	1,4-Dichlorobenzene	B0139	0.30	--	1	7.5[b]	7.5
	Antimony	B0139	15	43.26	10	6[b]	43.26
	Arsenic	B0139, B0238	0.0071	27.34	1	10[b]	27.34
	Benzene	B0139	0.11	--	0.5	5[b]	5
	Chloroethane	B0139	4.6	--	1	--	4.6
	Manganese	B0139, B0237	876	8,140	100	--	8,140
	Pentachlorophenol	B0139	1	--	25	1[b]	25
	Thallium	B0139	2.4	12.97	2	0.5[c]	12.97
	Trichloroethene	B0139	2.9	--	1	5[b]	5

Notes: All concentrations shown in micrograms per liter (μg/L).

a Chemical-specific ARARs are discussed in Section 4.2.
b The ARAR shown is the Federal primary MCL.
c The ARAR shown is the Federal MCLG.

-- Not applicable or not available
ARAR Applicable or relevant and appropriate requirement
HGAL Hunters Point groundwater ambient level
MCL Maximum Contaminant Level
MCLG Maximum Contaminant Level Goal
IR Installation Restoration
RBC Exposure scenario-specific risk-based concentration

TABLE 3-20: REMEDIATION GOALS FOR CHEMICALS OF CONCERN IN SEDIMENT

Parcel B Technical Memorandum in Support of a Record of Decision Amendment
Hunters Point Shipyard, San Francisco, California

Exposure Scenario	Chemical of Concern[a]	Redevelopment Block	RBC	HPAL	Laboratory Practical Quantitation Limit	Remediation Goal
Ecological receptor	Aluminum	BOS-1, BOS-3	3,400	--	1.0	3,400
	Copper	BOS-1, BOS-3	270	124	0.1	270
	Dibenz(a,h)anthracene	BOS-1, BOS-3	0.26	--	0.33	0.33
	Dieldrin	BOS-1, BOS-3	0.008	--	0.004	0.008
	Lead	BOS-1, BOS-3	218	8.99	0.1	218
	Methoxychlor	BOS-1, BOS-3	0.4	--	0.015	0.4
	Total Aroclors	BOS-1, BOS-3	0.18	--	0.02	0.18
	Total DDT	BOS-1, BOS-3	0.046	--	0.009	0.046
	Zinc	BOS-1, BOS-3	410	110	0.09	410

Notes: All concentrations shown in milligrams per kilogram (mg/kg).

a Chemicals of concern shown are based on the results of the screening-level ecological risk assessment.

--	Not applicable
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
HPAL	Hunters Point ambient level
RBC	Risk-based concentration
Total Aroclors	Summed concentration of Aroclors
Total DDT	Summed concentration of DDT and its metabolites (DDD and DDE)

TABLE 3-21: INCREMENTAL RISK: RISK AND HAZARD DRIVERS BY PLANNED REUSE AND ASSOCIATED SAMPLING LOCATIONS EXCEEDING REMEDIATION GOALS, SURFACE SOIL (0 TO 2 FEET BGS)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

													Significant Sampling Information			
Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME HI	RME Segregated HI		COC	Chemical-Specific Cancer Risk	Chemical-Specific HI	DF	RME EPC (mg/kg)	Remediation Goal (mg/kg)	Sampling Location	Sampling Top Depth (feet bgs)	Sampling Bottom Depth (feet bgs)	Detected Concentration (mg/kg)
3	RD	B1028	6E-06	8E+00	8E+00	Metal	ANTIMONY	--	6.65E+00	1/1	6.79E+01	10	0704P50	1	1.5	67.9
							ZINC	--	1.03E+00	1/1	3.83E+02	373	0704P50	1	1.5	383
						PAH	BENZO(A)PYRENE	1.23E-06	--	1/1	4.60E-02	0.33	No samples exceed remediation goals			
						Pest/PCB	HEPTACHLOR EPOXIDE	3.71E-06	1.59E-01	1/1	2.00E-03	0.002	No samples exceed remediation goals			
3	RD	B1029	7E-06	<1	<1	Pest/PCB	DIELDRIN	3.03E-06	1.93E-02	1/2	2.00E-03	0.004	No samples exceed remediation goals			
						SVOC	BIS(2-ETHYLHEXYL)PHTHALATE	1.75E-06	3.20E-02	1/2	2.00E+00	1.1	0704P44	1.5	2	2
3	RD	B1130	6E-06	3E+00	2E+00	Metal	COPPER	--	2.36E+00	1/1	3.76E+02	159	0704P35	1	1.5	376
						PAH	BENZO(A)PYRENE	4.29E-06	--	1/1	1.60E-01	0.33	No samples exceed remediation goals			
3	RD	B1131	2E-05	3E+00	3E+00	Metal	COPPER	--	2.71E+00	1/1	4.32E+02	159	0704P51	1	1.5	432
						PAH	BENZO(A)ANTHRACENE	1.30E-06	--	1/1	4.80E-01	0.37	0704P51	1	1.5	0.48
							BENZO(A)PYRENE	1.13E-05	--	1/1	4.20E-01	0.33	0704P51	1	1.5	0.42
							BENZO(B)FLUORANTHENE	1.45E-06	--	1/1	4.90E-01	0.34	0704P51	1	1.5	0.49
							DIBENZ(A,H)ANTHRACENE	1.35E-06	--	1/1	7.80E-02	0.33	No samples exceed remediation goals			
3	RD	B1231	1E-05	2E+00	2E+00	Metal	COPPER	--	1.77E+00	1/1	2.82E+02	159	0704P56	1	1.5	282
						PAH	BENZO(A)ANTHRACENE	1.38E-06	--	1/1	5.10E-01	0.37	0704P56	1	1.5	0.51
							BENZO(A)PYRENE	9.92E-06	--	1/1	3.70E-01	0.33	0704P56	1	1.5	0.37
3	RD	B1330	3E-04	4E+00	2E+00	Metal	ARSENIC	2.93E-04	7.15E-01	1/1	1.12E+01	11.1	0704P61	1.5	2	11.2
							COPPER	--	1.89E+00	1/1	3.01E+02	159	0704P61	1.5	2	301
						PAH	BENZO(A)PYRENE	2.25E-06	--	1/1	8.40E-02	0.33	No samples exceed remediation goals			
6	RD	B1626	6E-06	<1	<1	VOC	TETRACHLOROETHENE	5.80E-06	7.37E-02	1/1	2.80E+00	0.48	IR23B013	1.75	1.75	2.8
6	RD	B2224	6E-06	--	--	PAH	BENZO(A)PYRENE	3.48E-06	--	1/1	1.30E-01	0.33	No samples exceed remediation goals			
7	MU	B3228	1E-09	3E+00	3E+00	Metal	MANGANESE	--	2.74E+00	5/5	2.31E+03	1,431	3229N1A	1.5	2	2,180
													PA42SS06	1.25	1.25	2,640
7	MU	B3229	--	2E+00	2E+00	Metal	MANGANESE	--	1.72E+00	1/1	1.45E+03	1,431	PA42B004	1.75	1.75	1,450
8	MU	B2723	2E-06	<1	<1	VOC	TRICHLOROETHENE	1.66E-06	5.65E-03	1/1	4.90E+00	2.9	2725N4B	1.5	2	4.9
8	MU	B2923	1E-07	3E+00	3E+00	Metal	MANGANESE	--	2.25E+00	1/1	1.90E+03	1,431	IR10B017	1.25	1.25	1,900
8	MU	B3426	--	<1	<1	Metal	LEAD	--	--	1/1	1.63E+02	155	IR10B008	0.75	0.75	163
9	MU	B2818	2E-06	--	--	PAH	BENZO(A)PYRENE	1.29E-06	--	1/3	4.80E-02	0.33	No samples exceed remediation goals			
12	MU	B4220	--	2E+00	2E+00	Metal	MANGANESE	--	2.42E+00	3/3	2.04E+03	1,431	0201SWA	1	3	1,460
													0201SWB	1	3	2,040
12	MU	B4615	--	3E+00	3E+00	Metal	MANGANESE	--	2.84E+00	1/1	2.39E+03	1,431	IR26B034	1.75	1.75	2,390
15	MU	B4716	4E-05	4E+00	2E+00	Metal	MANGANESE	--	1.71E+00	2/2	1.44E+03	1,431	IR26B025	1.75	1.75	1,440
						PAH	BENZO(A)ANTHRACENE	3.24E-06	--	1/4	1.20E+00	0.37	IR26B026	1.75	1.75	1.2
							BENZO(A)PYRENE	2.36E-05	--	1/4	8.80E-01	0.33	IR26B026	1.75	1.75	0.88
							BENZO(B)FLUORANTHENE	5.32E-06	--	1/4	1.80E+00	0.34	IR26B026	1.75	1.75	1.8
							BENZO(K)FLUORANTHENE	1.27E-06	--	1/4	4.30E-01	0.34	IR26B026	1.75	1.75	0.43
							DIBENZ(A,H)ANTHRACENE	6.56E-06	--	1/4	3.80E-01	0.33	IR26B026	1.75	1.75	0.38
							INDENO(1,2,3-CD)PYRENE	2.85E-06	--	1/4	9.90E-01	0.35	IR26B026	1.75	1.75	0.99
BOS-1	OS	AF09	6E-07	<1	<1	Metal	LEAD	--	--	2/2	3.40E+02	155	IR07IT004	0	0.5	340
BOS-1	OS	AG09	3E-06	<1	<1	Metal	LEAD	--	--	6/6	1.62E+02	155	IR07IT012	0	0.5	210
														1.5	2	180
						Pest/PCB	AROCLOR-1260	1.41E-06	2.65E-01	6/6	1.05E+00	0.74	IR07IT011	0	0.5	1.6
														1.5	2	0.83

TABLE 3-21: INCREMENTAL RISK: RISK AND HAZARD DRIVERS BY PLANNED REUSE AND ASSOCIATED SAMPLING LOCATIONS EXCEEDING REMEDIATION GOALS, SURFACE SOIL (0 TO 2 FEET BGS) (CONTINUED)
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME HI	RME Segregated HI	COC		Chemical-Specific Cancer Risk	Chemical-Specific HI	DF	RME EPC (mg/kg)	Remediation Goal (mg/kg)	Significant Sampling Information			
													Sampling Location	Sampling Top Depth (feet bgs)	Sampling Bottom Depth (feet bgs)	Detected Concentration (mg/kg)
BOS-1	OS	AH09	8E-06	<1	<1	Metal	LEAD	--	--	9/9	5.36E+02	155	IR07IT013	0	0.5	190
														1.5	2	190
													IR07IT014	0	0.5	800
														1.5	2	770
													IR07IT020	0	0.5	340
														0	0.5	310
														1.5	2	690
														1.5	2	630
						PAH	BENZO(A)PYRENE	1.46E-06	--	7/9	1.90E-01	0.33	IR07IT020	0	0.5	0.66
						Pest/PCB	AROCLOR-1260	4.71E-06	8.82E-01	8/8	3.50E+00	0.74	IR07IT020	0	0.5	3.7
														1.5	2	3.5
BOS-1	OS	AI08	4E-06	<1	<1	PAH	BENZO(A)PYRENE	2.26E-06	--	6/8	2.96E-01	0.33	IR07IT016	0	0.5	0.46
BOS-3	OS	AU05	1E-05	<1	<1	Metal	LEAD	--	--	6/6	7.60E+02	155	IR26IT001	0	0.5	760
						PAH	BENZO(A)PYRENE	3.90E-06	--	4/9	5.10E-01	0.33	IR26IT001	1.5	2	0.51
						Pest/PCB	AROCLOR-1254	1.48E-06	2.77E-01	1/7	1.10E+00	0.093	IR26IT001	0	0.5	1.1
							AROCLOR-1260	4.17E-06	7.81E-01	3/7	3.10E+00	0.74	IR26IT001	0	0.5	3.1
BOS-3	OS	AW03	8E-05	<1	<1	Metal	ARSENIC	7.54E-05	2.08E-01	2/2	2.80E+01	11.1	IR26IT007	0	0.5	28
							LEAD	--	--	2/2	2.30E+02	155	IR26IT007	0	0.5	230
						Pest/PCB	AROCLOR-1260	3.64E-06	6.81E-01	2/2	2.70E+00	0.74	IR26IT007	0	0.5	2.7

Notes:

--	Not applicable
bgs	Below ground surface
COC	Chemical of concern
DF	Detection frequency
EPC	Exposure point concentration
HI	Hazard index
mg/kg	Milligram per kilogram
MU	Mixed use (residential exposure scenario)
OS	Open space (recreational exposure scenario)
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl
Pest	Pesticide
RD	Research and development (residential exposure scenario)
RME	Reasonable maximum exposure
SVOC	Semivolatile organic compound

TABLE 3-22: INCREMENTAL RISK: RISK AND HAZARD DRIVERS BY PLANNED REUSE AND ASSOCIATED SAMPLING LOCATIONS EXCEEDING REMEDIATION GOALS, SUBSURFACE SOIL (0 TO 10 FEET BGS)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME HI	RME Segregated HI		COC	Chemical-Specific Cancer Risk	Chemical-Specific HI	DF	RME EPC (mg/kg)	Remediation Goal (mg/kg)	Significant Sampling Information: Sampling Location	Sampling Top Depth (feet bgs)	Sampling Bottom Depth (feet bgs)	Detected Concentration (mg/kg)
1	MU	B0143	2E-06	<1	<1	PAH	BENZO(A)PYRENE	1.58E-06	--	2/2	5.90E-02	0.33	No samples exceed remediation goals			
1	MU	B0144	2E-06	<1	<1	PAH	BENZO(A)PYRENE	1.37E-06	--	2/4	5.10E-02	0.33	No samples exceed remediation goals			
2	RD	B0142	9E-06	<1	<1	Metal	LEAD	--	--	7/7	2.31E+02	155	1802BC14	10	10	325
						PAH	BENZO(A)PYRENE	2.87E-06	--	5/7	1.07E-01	0.33	No samples exceed remediation goals			
							DIBENZ(A,H)ANTHRACENE	4.06E-06	--	2/5	2.35E-01	0.33	1802BC14	10	10	0.38
2	RD	B0238	2E-06	<1	<1	PAH	BENZO(A)PYRENE	1.46E-06	--	5/6	5.44E-02	0.33	No samples exceed remediation goals			
2	RD	B0239	2E-06	<1	<1	PAH	BENZO(A)PYRENE	1.34E-06	--	3/3	5.00E-02	0.33	No samples exceed remediation goals			
2	RD	B0240	3E-06	<1	<1	PAH	BENZO(A)PYRENE	1.26E-06	--	3/3	4.70E-02	0.33	No samples exceed remediation goals			
2	RD	B0241	7E-06	<1	<1	PAH	BENZO(A)PYRENE	3.76E-06	--	13/14	1.40E-01	0.33	No samples exceed remediation goals			
2	RD	B0242	9E-06	<1	<1	PAH	BENZO(A)PYRENE	5.90E-06	--	3/3	2.20E-01	0.33	No samples exceed remediation goals			
2	RD	B0336	5E-08	<1	<1	Metal	LEAD	--	--	3/3	2.40E+02	155	IR18B016	6.25	6.25	240
2	RD	B0341	3E-06	<1	<1	PAH	BENZO(A)PYRENE	1.48E-06	--	8/9	5.50E-02	0.33	No samples exceed remediation goals			
2	RD	B0438	3E-07	<1	<1	Metal	LEAD	--	--	5/5	4.78E+02	155	0337B0A	10	10	478
2	RD	B0538	--	3E+00	2E+00	Metal	VANADIUM	--	2.30E+00	3/3	1.49E+02	117	IR18B017	4.25	4.25	140
													IR18B017	6.75	6.75	149
2	RD	B1036	3E-06	<1	<1	PAH	BENZO(A)PYRENE	2.04E-06	--	2/4	7.60E-02	0.33	No samples exceed remediation goals			
3	RD	B0532	4E-06	<1	<1	PAH	BENZO(A)PYRENE	3.48E-06	--	2/2	1.30E-01	0.33	No samples exceed remediation goals			
3	RD	B0632	5E-09	3E+00	3E+00	Metal	IRON	--	2.70E+00	1/1	5.93E+04	58,000	IR07B013	6.25	6.25	59,300
3	RD	B1028	7E-06	1E+01	7E+00	Metal	ANTIMONY	--	6.65E+00	5/6	6.79E+01	10	0704P50	1	1.5	67.9
							IRON	--	2.31E+00	6/6	5.07E+04	58,000	0704P14	8	8.5	64,300
							LEAD	--	--	7/7	8.40E+02	155	0704BC53	10	10	490
														10	10	1,190
						PAH	BENZO(A)PYRENE	1.23E-06	--	4/7	4.60E-02	0.33	No samples exceed remediation goals			
						Pest/PCB	HEPTACHLOR EPOXIDE	3.71E-06	1.59E-01	1/6	2.00E-03	0.002	No samples exceed remediation goals			
3	RD	B1029	3E-04	8E+00	5E+00	PAH	BENZO(A)PYRENE	1.10E-06	--	6/7	4.10E-02	0.33	No samples exceed remediation goals			
						Pest/PCB	AROCLOR-1260	2.81E-05	5.44E+00	5/7	5.93E+00	0.21	0704P41	2.5	3	14
							DIELDRIN	2.73E-04	1.74E+00	3/7	1.80E-01	0.004	0704P41	2.5	3	0.18
													0704P45	3	3.5	0.008
														3	3.5	0.01
							HEPTACHLOR EPOXIDE	5.57E-06	2.38E-01	3/7	3.00E-03	0.002	0704P45	3	3.5	0.003
						SVOC	BIS(2-ETHYLHEXYL)PHTHALATE	1.75E-06	3.20E-02	1/7	2.00E+00	1.1	0704P44	1.5	2	2
3	RD	B1128	1E-05	2E+00	<1	Metal	LEAD	--	--	9/9	3.63E+02	155	0704BC55	10	10	416
														10	10	495
													0704P15	9	9.5	575
													0704P16	8	8.5	300
													0704P17	9	9.5	418
						PAH	BENZO(A)PYRENE	5.94E-06	--	5/12	2.22E-01	0.33	No samples exceed remediation goals			
3	RD	B1129	1E-04	1E+01	7E+00	Metal	ANTIMONY	--	5.34E+00	10/10	5.46E+01	10	0704BC92	5	5	15.9
													0704P37	3	3.5	78.1
													0704P38	4	4.5	12.9
							COPPER	--	2.20E+00	10/10	3.49E+02	159	0704P36	2	2.5	335
													0704P38	4	4.5	365
							ZINC	--	1.59E+00	10/10	5.92E+02	373	0704P37	3	3.5	958
													0704P38	4	4.5	416
													0704P40	3.5	4	429
						PAH	BENZO(A)PYRENE	2.28E-06	--	8/10	8.51E-02	0.33	No samples exceed remediation goals			

TABLE 3-22: INCREMENTAL RISK: RISK AND HAZARD DRIVERS BY PLANNED REUSE AND ASSOCIATED SAMPLING LOCATIONS EXCEEDING REMEDIATION GOALS, SUBSURFACE SOIL (0 TO 10 FEET BGS) (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME HI	RME Segregated HI		COC	Chemical-Specific Cancer Risk	Chemical-Specific HI	DF	RME EPC (mg/kg)	Remediation Goal (mg/kg)	Significant Sampling Information: Sampling Location	Sampling Top Depth (feet bgs)	Sampling Bottom Depth (feet bgs)	Detected Concentration (mg/kg)
3	RD	B1129	1E-04	1E+01	7E+00	Pest/PCB	AROCLOR-1254	1.33E-06	2.08E-01	4/10	1.24E-01	0.093	0704BC92	5	5	0.095
													0704P38	4	4.5	0.16
													0704P40	3.5	4	0.12
							AROCLOR-1260	1.18E-05	2.29E+00	7/10	2.50E+00	0.21	0704BC92	5	5	0.27
													0704P37	3	3.5	2.5
													0704P38	4	4.5	0.44
							BETA-BHC	1.21E-06	1.71E-02	2/10	8.00E-03	0.0066	0704P38	2	2.5	0.008
							DIELDRIN	6.38E-05	4.05E-01	5/10	4.20E-02	0.004	0704BC92	5	5	0.01
													0704P37	3	3.5	0.051
													0704P38	2	2.5	0.01
														4	4.5	0.017
													0704P40	3.5	4	0.009
							HEPTACHLOR EPOXIDE	8.15E-06	3.48E-01	4/10	4.39E-03	0.002	0704P37	3	3.5	0.008
													0704P38	4	4.5	0.004
													0704P40	3.5	4	0.003
						SVOC	BIS(2-ETHYLHEXYL)PHTHALATE	8.15E-06	1.49E-01	2/10	9.30E+00	1.1	0704P38	4	4.5	9.3
													0704P40	3.5	4	3.2
3	RD	B1130	1E-04	1E+01	6E+00	Metal	ANTIMONY	--	4.84E+00	7/7	4.95E+01	10	0704BC88	5	5	37.3
													0704P35	4	4.5	49.5
							COPPER	--	4.01E+00	7/7	6.38E+02	159	0704P33	2	2.5	1120
														4	4.5	500
													0704P35	1	1.5	376
														4	4.5	327
							IRON	--	2.02E+00	7/7	4.43E+04	58,000	0704P33	2	2.5	61,000
							LEAD	--	--	7/7	1.64E+02	155	0704P33	2	2.5	174
													0704P35	4	4.5	203
						PAH	BENZO(B)FLUORANTHENE	2.01E-06	--	6/7	6.80E-01	0.34	0704P33	2	2.5	0.68
							BENZO(K)FLUORANTHENE	1.54E-06	--	6/7	5.20E-01	0.34	0704P33	2	2.5	0.52
							DIBENZ(A,H)ANTHRACENE	1.52E-06	--	5/7	8.82E-02	0.33	No samples exceed remediation goals			
						Pest/PCB	AROCLOR-1260	3.00E-06	5.82E-01	6/7	6.34E-01	0.21	0704BC87	5	5	0.23
													0704BC88	5	5	0.68
													0704P35	4	4.5	1.1
							DIELDRIN	4.31E-05	2.74E-01	4/7	2.84E-02	0.004	0704BC88	5	5	0.028
													0704P34	3	3.5	0.005
													0704P35	4	4.5	0.054
							HEPTACHLOR EPOXIDE	2.79E-05	1.19E+00	5/7	1.50E-02	0.002	0704BC88	5	5	0.004
													0704P34	3	3.5	0.005
													0704P35	4	4.5	0.015
3	RD	B1131	3E-04	1E+01	4E+00	Metal	ARSENIC	2.39E-04	5.85E-01	6/7	9.16E+00	11.1	0704P51	3	3.5	13.3
							COPPER	--	3.58E+00	7/7	5.71E+02	159	0704P32	2.5	3	754
													0704P51	1	1.5	432
														3	3.5	826
							IRON	--	2.26E+00	7/7	4.95E+04	58,000	0704P51	3	4	63,200
							MERCURY	--	1.63E+00	7/7	2.60E+00	2.3	0704P51	3	3.5	2.6

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME HI	RME Segregated HI		COC	Chemical-Specific Cancer Risk	Chemical-Specific HI	DF	RME EPC (mg/kg)	Remediation Goal (mg/kg)	Significant Sampling Information			
													Sampling Location	Sampling Top Depth (feet bgs)	Sampling Bottom Depth (feet bgs)	Detected Concentration (mg/kg)
3	RD	B1131	3E-04	1E+01	4E+00	PAH	BENZO(A)ANTHRACENE	1.08E-06	--	7/7	3.98E-01	0.37	0704P32	2.5	3	0.57
													0704P51	1	1.5	0.48
							BENZO(A)PYRENE	8.47E-06	--	7/7	3.16E-01	0.33	0704P32	2.5	3	0.4
													0704P51	1	1.5	0.42
							BENZO(B)FLUORANTHENE	1.05E-06	--	7/7	3.56E-01	0.34	0704P32	2.5	3	0.46
													0704P51	1	1.5	0.49
							DIBENZ(A,H)ANTHRACENE	1.35E-06	--	4/7	7.80E-02	0.33	No samples exceed remediation goals			
						Pest/PCB	HEPTACHLOR EPOXIDE	1.86E-06	7.93E-02	1/7	1.00E-03	0.002	No samples exceed remediation goals			
3	RD	B1228	3E-06	2E+00	<1	Metal	LEAD	--	--	5/5	2.41E+02	155	0704BC58	10	10	206
														10	10	209
													0704BC59	10	10	286
						PAH	BENZO(A)PYRENE	1.84E-06	--	6/6	6.88E-02	0.33	No samples exceed remediation goals			
3	RD	B1229	3E-06	2E+00	<1	Metal	LEAD	--	--	5/5	5.58E+02	155	0704BC74	5	5	242
													0704BC75	5	5	418
													0704BC76	5	5	707
						PAH	BENZO(A)PYRENE	2.01E-06	--	5/5	7.51E-02	0.33	No samples exceed remediation goals			
3	RD	B1230	2E-05	3E+00	2E+00	Metal	ANTIMONY	--	1.61E+00	5/5	1.64E+01	10	0704BC89	5	5	44.3
							LEAD	--	--	5/5	1.77E+02	155	0704BC89	5	5	211
													0704BC91	5	5	184
						PAH	BENZO(A)PYRENE	2.57E-06	--	5/5	9.58E-02	0.33	No samples exceed remediation goals			
						Pest/PCB	AROCLOR-1260	1.09E-06	2.11E-01	1/5	2.30E-01	0.21	0704BC89	5	5	0.3
							DIELDRIN	1.29E-05	8.19E-02	1/5	8.50E-03	0.004	0704BC89	5	5	0.006
														5	5	0.011
3	RD	B1231	1E-05	2E+00	2E+00	Metal	COPPER	--	1.51E+00	4/4	2.40E+02	159	0704P56	1	1.5	282
						PAH	BENZO(A)ANTHRACENE	1.38E-06	--	1/4	5.10E-01	0.37	0704P56	1	1.5	0.51
3	RD	B1231	1E-05	2E+00	2E+00	PAH	BENZO(A)PYRENE	9.92E-06	--	2/4	3.70E-01	0.33	0704P56	1	1.5	0.37
3	RD	B1328	7E-06	1E+01	9E+00	Metal	MANGANESE	--	4.72E+00	5/5	3.98E+03	1,431	0704P21	2.5	3	3,980
							MERCURY	--	3.77E+00	5/5	6.00E+00	2.3	0704P20	9.5	10	6
						Pest/PCB	AROCLOR-1260	1.09E-06	2.11E-01	2/5	2.30E-01	0.21	0704P26	3	3.5	0.23
							DIELDRIN	4.55E-06	2.89E-02	2/5	3.00E-03	0.004	No samples exceed remediation goals			
3	RD	B1329	6E-06	2E+00	<1	PAH	BENZO(A)PYRENE	2.33E-06	--	3/3	8.70E-02	0.33	No samples exceed remediation goals			
3	RD	B1330	3E-03	1E+01	8E+00	Metal	ARSENIC	3.24E-03	7.91E+00	5/5	1.24E+02	11.1	0704BC93	5	5	240
													0704P60	2.5	3	16.5
														3	3.5	13.4
													0704P61	1.5	2	11.2
							COPPER	--	2.61E+00	5/5	4.15E+02	159	0704BC93	5	5	220
													0704P60	2.5	3	595
														3	3.5	419
													0704P61	1.5	2	301
														2.5	3	239
						PAH	BENZO(A)ANTHRACENE	1.85E-06	--	4/5	6.85E-01	0.37	0704BC93	5	5	0.43
														5	5	0.94
							BENZO(A)PYRENE	6.70E-06	--	4/5	2.50E-01	0.33	No samples exceed remediation goals			
							NAPHTHALENE	2.25E-06	6.68E-02	1/5	3.75E+00	1.7	0704BC93	5	5	1.9
														5	5	5.6
3	RD	B1330	3E-03	1E+01	8E+00	Pest/PCB	AROCLOR-1254	5.27E-06	8.20E-01	1/5	4.90E-01	0.093	0704P61	2.5	3	0.49
							DIELDRIN	2.58E-05	1.64E-01	1/5	1.70E-02	0.004	0704P61	2.5	3	0.017
							HEPTACHLOR EPOXIDE	7.43E-06	3.17E-01	1/5	4.00E-03	0.002	0704P61	2.5	3	0.004
3	RD	B1331	1E-03	6E+00	3E+00	Metal	ARSENIC	1.31E-03	3.19E+00	2/2	5.00E+01	11.1	0704BC94	5	5	50
							COPPER	--	2.07E+00	2/2	3.30E+02	159	0704BC94	5	5	330

TABLE 3-22: INCREMENTAL RISK: RISK AND HAZARD DRIVERS BY PLANNED REUSE AND ASSOCIATED SAMPLING LOCATIONS EXCEEDING REMEDIATION GOALS, SUBSURFACE SOIL (0 TO 10 FEET BGS) (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME HI	RME Segregated HI		COC	Chemical-Specific Cancer Risk	Chemical-Specific HI	DF	RME EPC (mg/kg)	Remediation Goal (mg/kg)	Significant Sampling Information: Sampling Location	Sampling Top Depth (feet bgs)	Sampling Bottom Depth (feet bgs)	Detected Concentration (mg/kg)
5	RD	B1632	2E-06	<1	<1	PAH	BENZO(A)PYRENE	1.55E-06	--	2/3	5.80E-02	0.33	No samples exceed remediation goals			
5	RD	B2127	2E-06	<1	<1	PAH	BENZO(A)PYRENE	1.29E-06	--	4/9	4.80E-02	0.33	No samples exceed remediation goals			
5	RD	B2128	3E-06	<1	<1	PAH	BENZO(A)PYRENE	2.28E-06	--	1/4	8.50E-02	0.33	No samples exceed remediation goals			
5	RD	B2228	4E-06	<1	<1	PAH	BENZO(A)PYRENE	2.68E-06	--	1/2	1.00E-01	0.33	No samples exceed remediation goals			
6	RD	B1425	2E-06	<1	<1	PAH	BENZO(A)PYRENE	1.34E-06	--	1/4	5.00E-02	0.33	No samples exceed remediation goals			
6	RD	B1426	8E-06	4E+00	2E+00	Metal	CADMIUM	6.95E-09	1.19E+00	3/8	4.10E+00	3.5	IDLBC11	9	9	4.1
							MANGANESE	--	1.84E+00	3/3	1.55E+03	1,431	0704P22	7.5	8	1,550
						PAH	BENZO(A)PYRENE	2.68E-06	--	2/4	1.00E-01	0.33	No samples exceed remediation goals			
						Pest/PCB	DIELDRIN	3.03E-06	1.93E-02	1/2	2.00E-03	0.004	No samples exceed remediation goals			
6	RD	B1626	7E-06	2E+00	<1	PAH	BENZO(A)PYRENE	1.13E-06	--	1/7	4.20E-02	0.33	No samples exceed remediation goals			
						VOC	TETRACHLOROETHENE	5.80E-06	7.37E-02	1/7	2.80E+00	0.48	IR23B013	1.75	1.75	2.8
6	RD	B2026	2E-06	<1	<1	PAH	BENZO(A)PYRENE	1.21E-06	--	1/1	4.50E-02	0.33	No samples exceed remediation goals			
6	RD	B2224	6E-06	--	--	PAH	BENZO(A)PYRENE	3.48E-06	--	1/2	1.30E-01	0.33	No samples exceed remediation goals			
6	RD	B2226	3E-06	<1	<1	PAH	BENZO(A)PYRENE	2.16E-06	--	1/1	8.05E-02	0.33	No samples exceed remediation goals			
7	MU	B2635	7E-07	3E+00	3E+00	Metal	ZINC	--	2.79E+00	3/3	1.04E+03	373	4600B19	2.5	3	1,040
7	MU	B2727	--	6E+00	3E+00	Metal	IRON	--	3.03E+00	1/1	6.65E+04	58,000	PA50TA01	8.75	8.75	66,500
7	MU	B2735	4E-04	4E+00	3E+00	Metal	ARSENIC	3.94E-04	9.64E-01	2/2	1.51E+01	11.1	4600SNS	1	7	15.1
							ZINC	--	2.54E+00	2/2	9.47E+02	373	4600B21	2.5	3	947
						PAH	BENZO(A)PYRENE	1.39E-06	--	1/2	5.20E-02	0.33	No samples exceed remediation goals			
7	MU	B3128	--	2E+00	2E+00	Metal	MANGANESE	--	1.74E+00	6/6	1.47E+03	1,431	0421B0A	10	10	1,870
7	MU	B3228	7E-09	4E+00	3E+00	Metal	CADMIUM	6.10E-09	1.04E+00	4/4	3.60E+00	3.5	3229S1B	5	5.5	3.6
							MANGANESE	--	2.56E+00	18/18	2.15E+03	1,431	3229E1A	5	5.5	8,500
													3229E2A	5	5.5	1,580
													3229N1A	1.5	2	2,180
													3229N1B	2.5	3	1,800
														4.5	5	1,600
													PA42SS06	1.25	1.25	2,640
7	MU	B3229	1E-06	2E+00	2E+00	Metal	MANGANESE	--	1.72E+00	2/2	1.45E+03	1431	PA42B004	1.75	1.75	1,450
8	MU	B2722	1E-08	3E+00	2E+00	Metal	IRON	--	2.50E+00	4/4	5.49E+04	58,000	IR10B001	6.5	6.5	59,700
8	MU	B2723	1E-05	<1	<1	VOC	TRICHLOROETHENE	9.73E-06	3.30E-02	26/26	2.86E+01	2.9	1001W2A	3	3.5	20
													1001W2B	3	3.5	15
														8	8.5	5.9
													1001W3A	3	3.5	110
													1001W5A	3	3.5	15
													1001W6B	7.5	8	18
														8	8.5	16
													2725N4B	1.5	2	4.9
													IR10SG039	4	4.5	40.6
														5	5.5	4.1
8	MU	B2723	1E-05	<1	<1	VOC	TRICHLOROETHENE	9.73E-06	3.30E-02	26/26	2.86E+01	2.9	IR10SG040	4.5	5	10.5
														8.5	9	75.9
													IR10SG041	3	3.5	121
														6.5	7	7.03

TABLE 3-22: INCREMENTAL RISK: RISK AND HAZARD DRIVERS BY PLANNED REUSE AND ASSOCIATED SAMPLING LOCATIONS EXCEEDING REMEDIATION GOALS, SUBSURFACE SOIL (0 TO 10 FEET BGS) (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME HI	RME Segregated HI		COC	Chemical-Specific Cancer Risk	Chemical-Specific HI	DF	RME EPC (mg/kg)	Remediation Goal (mg/kg)	Significant Sampling Information: Sampling Location	Sampling Top Depth (feet bgs)	Sampling Bottom Depth (feet bgs)	Detected Concentration (mg/kg)
8	MU	B2724	3E-05	<1	<1	VOC	TRICHLOROETHENE	3.40E-05	1.15E-01	21/22	1.00E+02	2.9	2725B2	6	6.5	5.4
														6.5	7	4.8
													2725N1A	2	2.5	16
													2725N1B	6	6.5	18
													2725N2A	2	2.5	20
														6	6.5	100
													2725SNA	1	7	6.3
													IR10GB002	9.5	9.5	10
													IR10VW03A	5	5.5	6.67
														9	9.5	20.3
8	MU	B2823	6E-05	2E+00	2E+00	Metal	MANGANESE	--	1.46E+00	21/21	1.23E+03	1,431	1001B1	3	3.5	1,770
													IR10B036	2.25	2.25	1,860
													IR10B037	2.25	2.25	3,210
						VOC	TRICHLOROETHENE	5.51E-05	1.87E-01	49/50	1.62E+02	2.9	1001B1	3	3.5	25
														6.5	7	5.5
													1001B2	3	3.5	230
														7	7.5	18
													1001B3	4	4.5	120
													1001W1A	3.5	4	48
													1001W1B	3	3.5	56
														7.5	8	6.4
														8	8.5	7.1
													IR10B035A	2.25	2.25	29
														3.75	3.75	180
														6.25	6.25	16
													IR10B036	2.25	2.25	3.5
														3.75	3.75	83
														6.25	6.25	17
													IR10B037	2.25	2.25	8.9
														3.75	3.75	48
														6.25	6.25	6.1
													IR10GB003	3.5	3.5	92
														8.5	8.5	12
													IR10GB004	3.5	3.5	18
													IR10SG042	5.5	6	18
														6.5	7	5.32
														7	7.5	30.2
													IR10SG043	6.5	7	14.8
														8.5	9	54.9
														9.5	10	30
													IR10SG044	4.5	5	5.16
														8.5	9	5.36

TABLE 3-22: INCREMENTAL RISK: RISK AND HAZARD DRIVERS BY PLANNED REUSE AND ASSOCIATED SAMPLING LOCATIONS EXCEEDING REMEDIATION GOALS, SUBSURFACE SOIL (0 TO 10 FEET BGS) (CONTINUED)
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME HI	RME Segregated HI		COC	Chemical-Specific Cancer Risk	Chemical-Specific HI	DF	RME EPC (mg/kg)	Remediation Goal (mg/kg)	Significant Sampling Information: Sampling Location	Sampling Top Depth (feet bgs)	Sampling Bottom Depth (feet bgs)	Detected Concentration (mg/kg)
8	MU	B2823	6E-05	2E+00	2E+00	VOC	TRICHLOROETHENE	5.51E-05	1.87E-01	49/50	1.62E+02	2.9	IR10VW01A	3.5	4	87.9
													IR10VW02A	4	4.5	18.3
														9	9.5	4.81
														5	5.5	27.8
														6.5	7	18.2
													IR10VW05A	9	9.5	125
													IR10VW06A	4.5	5	7.22
													IR10VW08A	2.5	3	78.4
														4.5	5	19.4
													IR10VW09A	6.5	7	16.6
														8.5	9	17.6
8	MU	B2824	1E-05	<1	<1	VOC	TRICHLOROETHENE	1.25E-05	4.25E-02	32/37	3.69E+01	2.9	1001S1A	3.5	4	58
														9	9.5	9.6
													1001S1B	3	3.5	100
													1001S2A	3.5	4	11
														9	9.5	71
													1001S2B	2.5	3	16
														8	8.5	41
													1001S2C	3.5	4	170
														7.5	8	17
													1001S3A	3	3.5	14
														8	8.5	12
													1001S3B	2.5	3	150
														8	8.5	9.1
													1001S3C	3.5	4	89
													1001S4B	8	8.5	3.2
													IR10GB005	9.5	9.5	20
													IR10GB007	9.5	9.5	25
													IR10SG045	3.5	4	41.7
														7	7.5	42.2
													IR10SG046	3.5	4	14.2
														6	6.5	5.06
													IR10VW11A	2.5	3	9.05
8	MU	B2923	2E-04	1E+01	1E+01	Metal	ARSENIC	1.32E-04	3.23E-01	5/10	5.06E+00	11.1	IR10B017	2.75	2.75	11.7
							MANGANESE	--	1.33E+01	11/11	1.12E+04	1,431	IR10B017	1.25	1.25	1,900
														2.75	2.75	41,400
						VOC	TRICHLOROETHENE	2.16E-05	7.32E-02	28/28	6.35E+01	2.9	1001E1A	4	4.5	4.3
													1001E2A	3	3.5	5.7
													1001E3A	3	3.5	5.8
													1002E2A	4	4.5	60
													1002E3A	3.5	4	65
														4	4.5	62
													1002N1A	3	3.5	46
													1002N2A	3	3.5	20
													1002W1A	3.5	4	16
													IR10GB008	5.5	5.5	7.5

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME HI	RME Segregated HI		COC	Chemical-Specific Cancer Risk	Chemical-Specific HI	DF	RME EPC (mg/kg)	Remediation Goal (mg/kg)	Significant Sampling Information: Sampling Location	Sampling Top Depth (feet bgs)	Sampling Bottom Depth (feet bgs)	Detected Concentration (mg/kg)
8	MU	B2923	2E-04	1E+01	1E+01	VOC	TRICHLOROETHENE	2.16E-05	7.32E-02	28/28	6.35E+01	2.9	IR10GB008	9	9	18
													IR10GB022	9.5	9.5	26
													IR10SG047	8	8.5	18.6
													IR10VW12A	4.5	5	11.2
														8.5	9	7.57
8	MU	B2924	7E-06	<1	<1	VOC	TRICHLOROETHENE	7.15E-06	2.43E-02	10/16	2.10E+01	2.9	1002S1A	4	4.5	26
													1002S1B	3	3.5	16
														5.5	6	3.3
														6	6.5	7.8
													1002S2A	3	3.5	7.1
													1002S3A	3	3.5	5.7
													IR10GB009	9.5	9.5	15
													IR10VW14A	6	6.5	13
														9	9.5	90.3
8	MU	B2926	1E-06	3E+00	2E+00	Metal	CADMIUM	1.34E-08	2.29E+00	3/13	7.90E+00	3.5	IDLB4B	5.5	5.5	5.1
													IDLBC04	6	6	7.9
8	MU	B3126	1E-07	2E+00	2E+00	Metal	MANGANESE	--	1.23E+00	19/19	1.04E+03	1,431	1005E1A	5.5	6	1,620
													1005W1A	6	6.5	1,540
8	MU	B3422	3E-06	<1	<1	PAH	BENZO(A)PYRENE	1.74E-06	--	3/8	6.50E-02	0.33	No samples exceed remediation goals			
8	MU	B3425	--	2E+00	2E+00	Metal	MANGANESE	--	1.53E+00	14/14	1.29E+03	1,431	3425SEA	1	6	1,730
													3425SSA	1	6	1,820
													3425SWA	1	6	1,780
													3425W1A	4	4.5	2,040
8	MU	B3426	1E-07	<1	<1	Metal	LEAD	--	--	4/4	1.63E+02	155	IR10B008	0.75	0.75	163
8	MU	B3622	6E-07	2E+00	2E+00	Metal	MANGANESE	--	1.92E+00	9/9	1.62E+03	1,431	3622B0A	10	10	1,630
													3622S1A	9	9.5	1,630
													3622SSA	1	7	2,230
9	MU	B2818	2E-06	--	--	PAH	BENZO(A)PYRENE	1.29E-06	--	1/3	4.80E-02	0.33	No samples exceed remediation goals			
9	MU	B3117	--	2E+00	2E+00	Metal	MANGANESE	--	1.61E+00	5/5	1.36E+03	1,431	2401N1A	3.5	4	1,470
9	MU	B3118	3E-07	2E+00	2E+00	Metal	MANGANESE	--	1.84E+00	25/25	1.55E+03	1,431	2401B3	8	8.5	1,490
													2401SNC	7	8	2,370
													2401SWA	1	7	1,660
													2401SWB	7	8	2,090
													2401W2A	3.5	4	2,640
														7.5	8	2,030
													2401W3A	3	3.5	1,740
														5.5	6	2,240
														7.5	8	1,460
													PA24B003	9.25	9.25	1,700
9	MU	B3215	6E-06	<1	<1	PAH	BENZO(A)PYRENE	2.95E-06	--	2/6	1.10E-01	0.33	No samples exceed remediation goals			
							DIBENZ(A,H)ANTHRACENE	1.03E-06	--	2/6	5.95E-02	0.33	No samples exceed remediation goals			
9	MU	B3217	--	2E+00	2E+00	Metal	MANGANESE	--	1.84E+00	2/2	1.55E+03	1,431	2401N2B	2.5	3	1,550
9	MU	B3218	--	2E+00	2E+00	Metal	MANGANESE	--	1.85E+00	6/6	1.56E+03	1,431	2401SEA	1	7	1,570
													2401SEB	7	8	1,750
9	MU	B3315	4E-06	<1	<1	PAH	BENZO(A)PYRENE	2.79E-06	--	5/13	1.04E-01	0.33	No samples exceed remediation goals			

TABLE 3-22: INCREMENTAL RISK: RISK AND HAZARD DRIVERS BY PLANNED REUSE AND ASSOCIATED SAMPLING LOCATIONS EXCEEDING REMEDIATION GOALS, SUBSURFACE SOIL (0 TO 10 FEET BGS) (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME HI	RME Segregated HI		COC	Chemical-Specific Cancer Risk	Chemical-Specific HI	DF	RME EPC (mg/kg)	Remediation Goal (mg/kg)	Significant Sampling Information: Sampling Location	Sampling Top Depth (feet bgs)	Sampling Bottom Depth (feet bgs)	Detected Concentration (mg/kg)
9	MU	B3415	3E-06	6E+00	3E+00	Metal	ANTIMONY	--	2.12E+00	3/3	2.17E+01	10	PA24B005	9.25	9.25	21.7
							IRON	--	3.40E+00	5/5	7.46E+04	58,000	PA24B005	6.75	6.75	83,200
														9.25	9.25	69,600
							LEAD	--	--	2/4	1.65E+02	155	PA24B005	2.75	2.75	165
						PAH	BENZO(A)PYRENE	1.72E-06	--	3/10	6.40E-02	0.33	No samples exceed remediation goals			
9	MU	B3421	2E-07	2E+00	2E+00	Metal	MANGANESE	--	1.90E+00	3/3	1.60E+03	1,431	IR10MW14A	4.25	4.25	1,590
														6.75	6.75	1600
9	MU	B3515	2E-06	<1	<1	PAH	BENZO(A)PYRENE	1.34E-06	--	3/10	5.00E-02	0.33	No samples exceed remediation goals			
12	MU	B3718	8E-09	2E+00	2E+00	Metal	MANGANESE	--	1.78E+00	9/9	1.50E+03	1,431	PA24B007	6.75	6.75	2320
12	MU	B3815	1E-06	5E+00	4E+00	Metal	MANGANESE	--	3.70E+00	4/4	3.12E+03	1,431	460BC41	10	10	1,700
													460BC42	10	10	1,930
													460S1AA	4	4.5	3,190
12	MU	B3816	3E-09	2E+00	2E+00	Metal	MANGANESE	--	1.60E+00	14/14	1.35E+03	1,431	0249B0A	10	10	1,760
													0249SSA	1	7	2,220
													0249SWB	7	10	2,170
12	MU	B3915	8E-06	<1	<1	PAH	BENZO(A)PYRENE	5.36E-06	--	3/14	2.00E-01	0.33	No samples exceed remediation goals			
12	MU	B3917	6E-06	<1	<1	PAH	BENZO(A)PYRENE	4.02E-06	--	3/7	1.50E-01	0.33	No samples exceed remediation goals			
12	MU	B3919	3E-06	--	--	PAH	BENZO(A)PYRENE	1.35E-06	--	2/2	5.05E-02	0.33	No samples exceed remediation goals			
12	MU	B4015	1E-06	2E+00	2E+00	Metal	MANGANESE	--	1.60E+00	8/8	1.35E+03	1,431	2408N1A	2.5	3	1,930
12	MU	B4016	2E-06	<1	<1	PAH	BENZO(A)PYRENE	1.02E-06	--	1/5	3.80E-02	0.33	No samples exceed remediation goals			
12	MU	B4017	2E-05	2E+00	2E+00	Metal	MANGANESE	--	2.17E+00	2/2	1.83E+03	1,431	4600B78	6	6	1,830
						PAH	BENZO(A)ANTHRACENE	1.92E-06	--	2/5	7.10E-01	0.37	4600B78	10	10	0.71
							BENZO(A)PYRENE	1.13E-05	--	2/5	4.20E-01	0.33	4600B78	10	10	0.42
							BENZO(B)FLUORANTHENE	1.63E-06	--	2/5	5.50E-01	0.34	4600B78	10	10	0.55
							BENZO(K)FLUORANTHENE	1.00E-06	--	2/5	3.40E-01	0.34	No samples exceed remediation goals			
							DIBENZ(A,H)ANTHRACENE	2.42E-06	--	1/5	1.40E-01	0.33	No samples exceed remediation goals			
12	MU	B4019	1E-06	3E+00	3E+00	Metal	MANGANESE	--	2.89E+00	9/9	2.43E+03	1,431	460BC09	6	6	3,520
													460E1Q	4.5	5	1,950
12	MU	B4020	7E-08	3E+00	3E+00	Metal	MANGANESE	--	2.86E+00	3/3	2.41E+03	1,431	460E1S	3	3.5	2,410
12	MU	B4116	--	3E+00	3E+00	Metal	MANGANESE	--	2.52E+00	13/13	2.13E+03	1,431	2408S2A	3	3.5	3030
													2408S3B	3	3.5	4,310
													2408S4A	7	7.5	1,800
													2408S5A	6.5	7	1,470
12	MU	B4217	--	2E+00	2E+00	Metal	MANGANESE	--	1.67E+00	5/5	1.41E+03	1,431	4217B0A	1	5.5	1,440
12	MU	B4219	1E-07	2E+00	2E+00	Metal	MANGANESE	--	1.74E+00	2/2	1.47E+03	1,431	IR20MW01A	5.25	5.25	1,470
12	MU	B4220	--	2E+00	2E+00	Metal	MANGANESE	--	1.55E+00	10/10	1.31E+03	1,431	0201SWA	1	3	1,460
													0201SWB	1	3	3,050
12	MU	B4315	8E-07	4E+00	3E+00	Metal	IRON	--	3.19E+00	1/1	7.00E+04	58,000	PA50TA02	9.75	9.75	70,000
12	MU	B4320	--	2E+00	2E+00	Metal	MANGANESE	--	1.64E+00	6/6	1.38E+03	1,431	IR20B002	6.75	6.75	1,450
12	MU	B4517	--	3E+00	2E+00	Metal	MANGANESE	--	2.22E+00	2/2	1.87E+03	1,431	IR26B033	6.25	6.25	1,870
12	MU	B4520	4E-06	<1	<1	Pest/PCB	AROCLOR-1260	3.70E-06	7.16E-01	3/7	7.80E-01	0.21	0202B0B	10	10	0.78
12	MU	B4615	--	3E+00	3E+00	Metal	MANGANESE	--	2.84E+00	2/2	2.39E+03	1,431	IR26B034	1.75	1.75	2,390
12	MU	B4617	2E-08	3E+00	2E+00	Metal	MANGANESE	--	2.29E+00	1/1	1.93E+03	1,431	IR26B031	7.25	7.25	1,930
15	MU	B4716	4E-05	5E+00	2E+00	Metal	IRON	--	1.89E+00	8/8	4.16E+04	58,000	IR26B010	6.25	6.25	32,100
							MANGANESE	--	1.71E+00	8/8	1.44E+03	1,431	IR26B010	6.25	6.25	2,030
													IR26B026	6.25	6.25	1,610

TABLE 3-22: INCREMENTAL RISK: RISK AND HAZARD DRIVERS BY PLANNED REUSE AND ASSOCIATED SAMPLING LOCATIONS EXCEEDING REMEDIATION GOALS, SUBSURFACE SOIL (0 TO 10 FEET BGS) (CONTINUED)

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Redevelopment Block	Planned Reuse	Grid Number	RME Cancer Risk	RME HI	RME Segregated HI		COC	Chemical-Specific Cancer Risk	Chemical-Specific HI	DF	RME EPC (mg/kg)	Remediation Goal (mg/kg)	Significant Sampling Information: Sampling Location	Sampling Top Depth (feet bgs)	Sampling Bottom Depth (feet bgs)	Detected Concentration (mg/kg)
15	MU	B4716	4E-05	5E+00	2E+00	PAH	BENZO(A)ANTHRACENE	3.24E-06	--	1/11	1.20E+00	0.37	IR26B026	1.75	1.75	1.2
							BENZO(A)PYRENE	2.36E-05	--	1/11	8.80E-01	0.33	IR26B026	1.75	1.75	0.88
							BENZO(B)FLUORANTHENE	5.32E-06	--	1/11	1.80E+00	0.34	IR26B026	1.75	1.75	1.8
							BENZO(K)FLUORANTHENE	1.27E-06	--	1/11	4.30E-01	0.34	IR26B026	1.75	1.75	0.43
							DIBENZ(A,H)ANTHRACENE	6.56E-06	--	1/11	3.80E-01	0.33	IR26B026	1.75	1.75	0.38
							INDENO(1,2,3-CD)PYRENE	2.85E-06	--	1/11	9.90E-01	0.35	IR26B026	1.75	1.75	0.99
16	E/C	AX04	1E-04	<1	<1	Metal	ARSENIC	1.27E-04	1.27E-01	4/7	5.52E+01	11.1	EE05BC04	10	10	55.2
													EE05BC05	10	10	45.6
						PAH	BENZO(A)PYRENE	4.56E-06	--	4/7	8.00E-01	0.33	EE05BC05	10	10	0.8
16	E/C	AY03	6E-05	<1	<1	Metal	ARSENIC	4.96E-05	4.94E-02	13/17	2.15E+01	11.1	EE05BC08	10	10	54.1
													EE05BC09	10	10	18.8
													EE05BC11	10	10	31.7
													EE05BC14	10	10	26.8
													EE05BC15	10	10	41.2
													EE05BC21	10	10	18.4
														10	10	12.6
													EE05BC22	10	10	14.6
						PAH	BENZO(A)ANTHRACENE	1.08E-06	--	13/17	1.90E+00	0.37	EE05BC11	10	10	1.9
													EE05BC14	10	10	1.8
							BENZO(A)PYRENE	1.16E-05	--	13/17	2.04E+00	0.33	EE05BC08	10	10	1.5
													EE05BC11	10	10	1.7
													EE05BC14	10	10	2.1
													EE05BC21	10	10	0.91
														10	10	1.2
16	E/C	AY04	1E-05	<1	<1	Metal	ARSENIC	1.40E-05	1.39E-02	6/11	6.08E+00	11.1	EE05BC07	10	10	12.4

Notes:

--	Not applicable
bgs	Below ground surface
COC	Chemical of concern
DF	Detection frequency
E/C	Educational/cultural (industrial exposure scenario)
EPC	Exposure point concentration
HI	Hazard index
mg/kg	Milligram per kilogram
MU	Mixed use (residential exposure scenario)
OS	Open space (recreational exposure scenario)
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl
Pest	Pesticide
RD	Research and development (residential exposure scenario)
RME	Reasonable maximum exposure
SVOC	Semivolatile organic compound
VOC	Volatile organic compound

4.0 REMEDIAL ACTION OBJECTIVES, GENERAL RESPONSE ACTIONS, AND PROCESS OPTIONS

This section presents (1) site-specific RAOs for soil, groundwater, soil gas, and sediment at Parcel B based on the COCs and remediation goals derived in Section 3.0 (see Section 4.1), (2) identifies ARARs (see Section 4.2), and (3) presents a range of GRAs and associated process options that will satisfy the RAOs (see Section 4.3). The GRAs and process options retained through the screening process will then be used in later sections as the basis for developing remedial alternatives.

4.1 REMEDIAL ACTION OBJECTIVES

RAOs are medium-specific goals for protecting human health and the environment. Each RAO should specify (1) the COCs, (2) the exposure route and receptors, and (3) an acceptable contaminant concentration or range of concentrations for each medium of concern (such as soil and groundwater). RAOs include both an exposure pathway and a contaminant concentration in a given medium because protectiveness may be achieved in two ways: limiting or eliminating the exposure pathway, or reducing contaminant concentrations.

The RAO evaluation for this Parcel B TMSRA is based on information gained during implementation of the remedy in the original ROD, updated risk evaluations for human health, and the SLERA. The NCP details the expectations for remedy selection in Title 40 of the *Code of Federal Regulations* (40 CFR) Part 300.430 (a)(1)(iii). These expectations were used to evaluate RAOs for Parcel B. In addition, the U.S. Department of Defense integrates these NCP expectations with the objectives of the BRAC program for expediting transfer of Department of Defense property for reuse and development.

An important component of developing RAOs is the determination of future land use. According to EPA's land-use directive (EPA 1995), RAOs "should reflect the reasonably anticipated future land use or uses...," thereby allowing for the development of "alternatives that would achieve cleanup levels associated with the reasonably anticipated future land use..." of the site. The EPA land-use directive states that "in cases where future land use is relatively certain, the RAOs generally should reflect this land use..." and "...need not include alternative land use scenarios..." (EPA 1995). RAOs developed for Parcel B are based on the city's planned reuse for each redevelopment block, which are considered the reasonable anticipated end use of the property, as described in the HHRA. In accordance with the EPA land-use directive, this TMSRA develops remedial alternatives based on the planned reuse only. Other reuse scenarios were developed in the HHRA and are included in Appendix A. These additional reuse scenarios are provided as a basis for implementing the RD if the currently proposed land use changes before the final record of decision.

4.1.1 Remedial Action Objectives for Soil

Separate RAOs are typically developed for human health receptors and for ecological receptors. Ecological RAOs were developed only for soil and sediment in shoreline areas. No ecological RAOs were developed for other soil at Parcel B because most of the land is paved and the parcel contains no identified terrestrial habitat.

The HHRA evaluated risk associated with each redevelopment block's planned reuse and associated exposure scenarios. The three exposure scenarios applicable to the planned reuse for the redevelopment blocks at Parcel B are residential, industrial, and recreational. A construction worker exposure scenario was also evaluated. The HHRA showed that the principal threats to human health from soil under these future land-use scenarios come from the ingestion, dermal contact, and inhalation exposure pathways.

4.1.1.1 Chemicals of Concern in Soil

The HHRA for Parcel B presents the potential risks for exposure to surface soils and subsurface soils based on planned reuse separately in Figures 3-5 and 3-6. Figure 3-7 presents the potential risks for the construction worker exposure scenario. The HHRA results in Appendix A indicate two COC groups that drive the risk at Parcel B: (1) metals, and (2) organic compounds. Figure 4-1 presents the grids that present a potential unacceptable risk from exposure to either surface or subsurface soils for the planned reuse and indicates which COC group (metals or organic compounds) is the primary risk driver in the grids. Where a grid presents a potential unacceptable risk and overlaps more than one redevelopment block, the COCs and remediation goals for the grids are assigned to the redevelopment block that contains the samples with the COCs that cause the potential unacceptable risk.

Figure 4-1 shows the risk grids where metals are the COCs (blue grids) that pose cancer risks greater than 1E-06 or where the highest segregated HI is greater than 1. As shown on Tables 3-11 and 3-12, the COCs for these grids include antimony, arsenic, cadmium, copper, iron, manganese, mercury, vanadium, and zinc. Grids where these metals are COCs that cause potential unacceptable risk are shaded blue on Figure 4-1. This figure also shows a blue star where lead is a COC. Figure 4-1 also shows the grids where organic compounds are the COCs (green grids) that pose cancer risks greater than 1E-06. As shown in Tables 3-11 and 3-12, the COCs for these grids include Aroclor-1254, Aroclor-1260, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, beta-benzene hexachloride, bis(2-ethylhexyl)-phthalate, dibenz(a,h)anthracene, dieldrin, heptachlor epoxide, indeno(1,2,3-cd)pyrene, naphthalene, tetrachloroethene, and trichloroethene. Figure 4-1 shows green grids with a cross-hatch pattern where both metals and organic compounds are COCs that present a potential unacceptable risk. Grids are shaded orange on Figure 4-1 where COCs were identified and their detected concentrations are below the established remediation goals.

Table 3-17 presents remediation goals for COCs in soil identified as presenting potential unacceptable risk based on planned reuse. The COCs and associated remediation goals for the construction worker are also presented in Table 3-17. These COCs and remediation goals form the basis for the soil RAOs presented later in this section.

4.1.1.2 Remedial Action Objectives for Soil by Exposure Pathways

The following RAOs apply to Parcel B soil:

- Prevent exposure to organic and inorganic compounds in soil above the remediation goals developed in the HHRA in Section 3.0 (see Table 3-17) for carcinogens or noncarcinogens for the following exposure pathways:
  - Ingestion of, outdoor inhalation of, and dermal exposure to soil from 0 to 10 feet bgs by residents in areas zoned for research and development or mixed-use reuse
  - Ingestion of homegrown produce by residents in areas zoned for research and development or mixed-use reuse
  - Ingestion of, outdoor inhalation of, and dermal exposure to soil from 0 to 10 feet bgs by industrial workers in areas zoned for educational/cultural reuse
  - Ingestion of, outdoor inhalation of, and dermal exposure to soil from 0 to 2 feet bgs by recreational users in areas zoned for open space reuse
  - Soil ingestion, outdoor air inhalation, and dermal exposure to soil from 0 to 10 feet bgs by construction workers in all areas
- Prevent exposure to VOCs in soil gas at concentrations that would pose unacceptable risk via indoor inhalation of vapors. Remediation goals for soil gas will be established during the RD.

The presence of methane in soil gas at concentrations that could be explosive poses a risk to human health at Redevelopment Block 3. The lowest concentration of methane in air that is explosive, known as the lower explosive limit, is 5 percent. Regulations for methane in soil gas use 5 percent and 1.25 percent in structures as reference criteria (see Section 4.2). As a result, the following RAO applies to methane at Parcel B:

- Prevent presence of methane in soil gas above a concentration of 1.25 percent (by volume in air).

The SLERA for Parcel B presents the potential risks to ecological receptors from exposure to sediment. The evaluation presented in Appendix B indicates a potential risk to benthic invertebrates, birds, and mammals from several metals, pesticides, and PCBs found in sediment along the Parcel B shoreline. Table 3-20 presents the COCs identified as presenting potential unacceptable risk and their remediation goals. As a result, the following RAO applies to soil and shoreline sediment at Parcel B:

- Prevent exposure of ecological receptors to organic and inorganic chemicals in soil and shoreline sediment in shoreline areas above remediation goals established for sediment.

4.1.2 Remedial Action Objectives for Groundwater

RAOs for Parcel B groundwater were evaluated based on (1) human health risks through inhalation of VOCs in indoor air (vapor intrusion) from the A-aquifer, (2) human health risks through the domestic use exposure pathway from the B-aquifer, (3) human health risks to construction workers from dermal exposure and inhalation from the A-aquifer, and (4) risks to ecological receptors from potential migration of COCs to San Francisco Bay. Section 4.1.2.1 discusses the plumes and COCs at Parcel B, and Sections 4.1.2.2 and 4.1.2.3 discuss the RAOs for protection of human health and the environment.

4.1.2.1 Groundwater Plumes and Chemicals of Concern

The potential risks from groundwater for Parcel B from exposure to VOCs in the A-aquifer through the vapor intrusion pathway and from domestic use of B-aquifer groundwater are described in the HHRA summary in Section 3.0 and are shown on Figures 3-8 and 3-9. The potential risk from groundwater to the construction worker is shown on Figure 3-10. As discussed in Section 3.2, VOCs in groundwater were not found to pose a risk to San Francisco Bay. Mercury is included as a COC because of its potential threat to the San Francisco Bay based on the results of the SLERA. Furthermore, chromium VI, copper, lead, and mercury were identified as COCs based on the potential migration of groundwater to the surface water of the bay.

Figure 3-8 shows the A-aquifer risk plumes derived for the HHRA. Figure 3-8 shows two plumes of VOCs and one of chromium VI; all these plumes are in the A-aquifer. The B-aquifer was evaluated in the HHRA in Appendix A for domestic use exposure scenarios. The HHRA concluded that groundwater in the B-aquifer did not contain concentrations exceeding remediation goals.

Three risk plumes were evaluated at Parcel B: IR-10A, IR-10B, and IR-25 (see Figure 3-8). In addition, several single-well locations were evaluated; three of these locations (grids B1528, B4516, and AY04) resulted in unacceptable risks. Table 3-14 lists the COCs for each plume and for the individual wells. The HHRA did not find unacceptable risk associated with plume IR-10B, which contains chromium VI as the COC. A focused investigation found that the chromium VI was confined to the immediate vicinity of well IR10MW12A (see Section 2.1.3.2). Chromium VI, copper, lead, and mercury are also included as COCs because of their potential threat to San Francisco Bay based on concentrations observed in six groundwater monitoring wells at Redevelopment Blocks, 8, 15, 16, BOS-1, and BOS-3. The nature and extent of metals in groundwater, including the plume for mercury, is discussed in Sections 2.3.2 and 3.4. Tables 3-18 and 3-19 list the remediation goals for A-aquifer and B-aquifer groundwater. Trigger levels for metals in groundwater are presented and discussed in Section 3.3.4.

Figure 4-2 shows a comparison of the risk plumes at Parcel B with the current extent of these plumes based on sample data for November 2004.

4.1.2.2 *Groundwater Remedial Action Objectives for the Protection of Human Health*

Exposure to VOCs in indoor air through the vapor intrusion pathway under the residential and industrial exposure scenario presents a potential unacceptable risk in some areas of Parcel B (see Section 3.0 and Appendix A). Vapor intrusion is not applicable in open space areas because it applies only to indoor air. As a result, the following RAO applies to groundwater at Parcel B:

- Prevent exposure to VOCs and mercury in A-aquifer groundwater above remediation goals via indoor inhalation of vapors from groundwater.

The A-aquifer is not considered a domestic use aquifer and, as a result, exposure to COCs via domestic use of groundwater is not a potentially complete pathway (see Section 2.2.4). The B-aquifer was assessed for potential domestic use exposure pathways (see Section 3.0 and Appendix A); the HHRA concluded that groundwater in the B-aquifer did not contain concentrations that exceeded remediation goals. The following RAO will be applied to assure that the domestic use pathway remains incomplete:

- Prevent direct exposure to B-aquifer groundwater that may contain COCs through the domestic use pathway.

Exposure to metals, VOCs, and semivolatile organic compounds in groundwater presents a potential unacceptable risk to construction workers at Parcel B. As a result, the following RAO applies to groundwater at Parcel B:

- Prevent or minimize exposure to metals, VOCs, and semivolatile organic compounds in the A-aquifer groundwater from dermal exposure and inhalation of vapors from groundwater by construction workers above remediation goals.

4.1.2.3 *Groundwater Remedial Action Objectives for the Protection of the Environment*

The current plumes of VOCs and chromium VI at Parcel B do not currently reach the bay (see Figure 2-7). Four COCs — chromium VI, copper, lead, and mercury — were identified that present a potential threat to San Francisco Bay based on concentrations that exceed trigger levels. As a result, the following RAO was developed to address potential migration of contaminated groundwater in the A-aquifer into San Francisco Bay that could affect surface water:

- Prevent or minimize migration of chromium VI, copper, lead, and mercury in A-aquifer groundwater that would result in concentrations of chromium VI above 50 μg/L, copper above 28.04 μg/L, lead above 14.44 μg/L, and mercury above 0.6 μg/L in the surface water of San Francisco Bay. This RAO is intended to provide protection of the beneficial uses of the bay, including protection of ecological receptors.

4.2 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Section 121(d)(l) of CERCLA requires remedial actions attain (or the decision document must justify the waiver of) any ARAR, which include environmental regulations, standards, or criteria, promulgated under federal or more stringent state laws. An ARAR may be either applicable or relevant and appropriate, but not both.

> Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address the situation at a CERCLA site. The requirement is applicable if the jurisdictional prerequisites of the standard show a direct correspondence when objectively compared to the conditions at the site. An applicable federal requirement is an ARAR. An applicable state requirement is an ARAR only if it is more stringent than federal ARARs.
>
> If the requirement is not legally applicable, then the requirement is evaluated to determine whether it is relevant and appropriate. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable, address problems or situations similar to the circumstances of the proposed response action and are well suited to the conditions of the site (EPA 1988a). A requirement must be determined to be both relevant and appropriate to be considered an ARAR.

Section 121(e) of CERCLA exempts any response action conducted entirely on site from having to obtain a federal, state, or local permit when the action is carried out in compliance with Section 121. In addition, on-site actions need only comply with the substantive requirements of ARARs, and not with the corresponding administrative procedures, such as administrative reviews and record-keeping requirements. Off-site actions must comply with all legally applicable requirements, both substantive and administrative.

The identification of ARARs is based on site-specific factors, including potential remedial actions, chemicals and compounds found at the site, physical characteristics of the site, and the location of the site. ARARs are usually divided into three categories: chemical-specific, location-specific, and action-specific.

As the lead federal agency, the Navy has primary responsibility for identification of potential ARARs for HPS Parcel B. The final identification of ARARs will be in the amended ROD. EPA guidance recommends that the lead federal agency consult with the state when identifying potential state ARARs for remedial actions (EPA 1988b). In conjunction with amending the ROD, the Navy requested that the state identify potential ARARs in October 2003. On December 24, 2003, DTSC responded and identified potential state ARARs. This response also included potential state ARARs identified by the Department of Fish and Game and the

Department of Health Services. The Water Board also submitted a response that identified potential state ARARs for remediation of soil and groundwater. To qualify as a state ARAR under CERCLA and the NCP, a state requirement must be (1) a standard, requirement, criterion, or limitation under a state environmental or facility siting law; (2) promulgated (of general applicability and legally enforceable); (3) substantive (not procedural or administrative); (4) more stringent than the federal requirement; (5) identified by the state in a timely manner; and (6) consistently applied. Requirements identified by these state agencies that the Navy identified as potential ARARs are presented in Appendix C.

The sections below summarize the potential federal and State of California ARARs for the Parcel B TMSRA. The ARARs related to sediment and soil gas are discussed together with the alternatives for soil for simplicity in presentation. The action-specific discussion is based on the remedial alternatives developed and described in Section 5.0 of this TMSRA. Only the substantive provisions of the specific citations discussed in the following sections are considered potential ARARs. Appendix C discusses the evaluation of ARARs in more detail.

4.2.1 Potential Chemical-Specific ARARs

Chemical-specific ARARs are the substantive provisions of health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, result in the establishment of numerical cleanup values. Chemical-specific ARARs for groundwater and soil are identified below.

4.2.1.1 Groundwater

The Navy has identified the substantive provisions of the following potential federal and state chemical-specific ARARs for groundwater:

- Federal maximum contaminant levels (MCL) for benzene, pentachlorophenol, trichloroethene, and 1,4-dichlorobenzene at 40 CFR § 141.61(a) and (c)
- Federal MCLs for antimony and arsenic at 40 CFR § 141.62(b)
- Federal maximum contaminant limit goal for thallium at 40 CFR § 141.51
- Resource Conservation and Recovery Act (RCRA) groundwater protection standards for development of site-specific concentration limits in *California Code of Regulations* (Cal. Code Regs.) Title (tit.) 22, Section (§) 66264.94(a)(1), (a)(3), (c), (d), and (e)
- The Navy accepts the substantive provisions of *California Water Code* (Cal. Water Code) Sections (§§) 13240, 13241, 13243, 13263(a), 13269, and 13360 of the Porter-Cologne Act as enabling legislation as implemented through the beneficial uses, water quality objectives, waste discharge requirements, promulgated policies of the Water Quality Control Plan for the San Francisco Bay Region, as potential state ARARs.

- The substantive provisions for groundwater relating to beneficial uses, water quality objectives, waste discharge requirements, and promulgated policies in Chapters 2 and 3 of the Comprehensive Water Quality Control Plan (Basin Plan) for the San Francisco Bay Region, except for the municipal and domestic supply designation for the A-aquifer
- State Water Resources Control Board Resolution 88-63, identifying exceptions to potential drinking water sources

There are potential federal and state chemical-specific ARARs for the groundwater alternatives that would generate waste, such as waste related to installation of monitoring wells. These potential ARARs are the substantive provisions of:

- RCRA hazardous waste definitions for waste generated in implementing the remedial alternatives at Cal. Code Regs. tit. 22 § 66261.21, 66261.22(a)(1), 66261.23, 66261.24(a)(1), and 66261.100
- Non-RCRA state regulated hazardous waste definitions at Cal. Code Regs. tit. 22 § 66261.22(a)(3) and (a)(4), § 66261.24(a)(2)-(a)(8), § 66261.101, and § 66261.3(a)(2)(C) or § 66261.3(a)(2)(F)
- Designated and nonhazardous solid waste definitions at Cal. Code Regs. tit. 27 §§ 20210 and 20220.

4.2.1.2 Surface Water

There is no surface water body on Parcel B. Groundwater at Parcel B has the potential to discharge to the bay, however. The Navy has therefore identified the substantive provisions of the California Toxics Rule (CTR) (40 CFR § 131.38) as potential federal chemical-specific ARARs and Table 3-3 of the Basin Plan as potential state chemical-specific ARARs for surface water at the interface of the A-aquifer groundwater and the bay. The Navy is evaluating groundwater monitoring as a component of Alternatives GW-2, GW-3A, and GW-3B in this TMSRA to monitor any direct release of contamination to the bay.

4.2.1.3 Soil

The Navy has identified the substantive provisions of the following potential federal chemical-specific ARAR for PCBs in soil:

- The risk-based cleanup and disposal approach to PCB remediation waste at 40 CFR § 761.61(c)

There are potential federal and state chemical-specific ARARs for the soil alternatives that would generate waste, such as excavation and off-site disposal of soil. These potential ARARs are:

- RCRA hazardous waste definitions for waste generated in implementing the remedial alternatives at Cal. Code Regs. tit. 22 § 66261.21, 66261.22(a)(1), 66261.23, 66261.24(a)(1), and 66261.100

- Non-RCRA state regulated hazardous waste definitions at Cal. Code Regs. tit. 22 § 66261.22(a)(3) and (a)(4), § 66261.24(a)(2)-(a)(8), § 66261.101, and § 66261.3(a)(2)(C) or § 66261.3(a)(2)(F)

- Designated and nonhazardous solid waste definitions at Cal. Code Regs. tit. 27 §§ 20210 and 20220

4.2.1.4 Air

The Navy has identified the substantive provisions of the following potential federal chemical-specific ARAR for the methane source removal:

- Cal. Code Regs. tit. 27, § 20921 (a)(1) and (a)(2), which requires operators of landfills to ensure that the concentration of methane gas does not exceed 1.25 percent by volume in air in any on-site structures and 5 percent by volume in air at the facility property boundary

4.2.2 Potential Location-Specific ARARs

The Navy has identified the substantive provisions of the following potential federal and state location-specific ARARs:

- Wetlands protection requirements to minimize the destruction, loss, or degradation of wetlands in Executive Order 11990 (codified at 40 CFR § 6.302[a])

- Requirement that activities comply with approved state coastal zone programs in the Coastal Zone Management Act (16 U.S.C. §§ 1456[c][1][A] and its accompanying implementing regulations in 15 CFR Part 930)

- Enabling legislation for the San Francisco Bay Plan in McAteer-Petris Act to reduce fill and disposal of dredged material in San Francisco Bay (California Government Code §§ 66600 through 66661)

- The approved state coastal zone management plan in the San Francisco Bay Plan to reduce fill and protect the beneficial uses of the bay (Cal. Code Regs. tit. 14 §§ 10110 through 11990)

4.2.3 Potential Action-Specific ARARs

Action-specific ARARs are technology- or activity-based requirements or limitations for remedial activities. These requirements are triggered by the specific remedial activities conducted at the site and indicate how a selected remedial alternative should be achieved. The Navy has identified the substantive provisions of potential action-specific ARARs for the soil and groundwater alternatives evaluated in the TMSRA.

4.2.3.1 Potential Action-Specific ARARs for Soil Alternatives

Remedial alternatives evaluated for Parcel B soil include the following types of actions, as discussed in more detail in Section 5.0: (1) no action; (2) institutional controls, maintained landscaping, and shoreline revetment; (3) excavation, methane and mercury source removal, maintained landscaping, institutional controls, and shoreline revetment; (4) covering portions of the site with soil, concrete, or asphalt, methane and mercury source removal, institutional controls, and shoreline revetment, and (5) excavation, methane and mercury source removal, covers, SVE, institutional controls, and shoreline revetment. The following discussion summarizes potential ARARs for these actions.

Institutional Controls

The Navy has identified the following potential state ARAR for institutional controls. The specific institutional control objectives are included in Section 5.0 with the discussion of each alternative.

The Navy has identified the substantive provisions of the following potential state action-specific ARARs for institutional controls:

- Requirements related to implementing institutional controls and entering into a covenant to restrict use of property with DTSC, at California Civil Code § 1471 and California Health and Safety Code §§ 25202.5, 25222.1, 25232(b)(1)(A)-(E), 25233(c), 25234, and 25355.5(a)(1)(C) and Cal. Code Regs. tit. 22 § 67391.1

Maintained Landscaping

The substantive provisions of the following requirement are potential state ARARs for covering soil excavations in areas of naturally occurring asbestos:

- Toxic control measures for airborne asbestos during construction, grading, quarrying, and surface mining operations at Cal. Code Regs. tit. 17, § 93105.

Pursuant to Cal. Code Regs. tit. 17, § 93105(e)(4)(G), upon completion of construction activities in areas of naturally occurring asbestos, the disturbed surfaces must be stabilized using one or more of the following methods:

- A vegetative cover
- Placement of at least 3 inches of non-asbestos-containing material
- Paving
- Any other measure deemed sufficient to prevent wind speeds of 10 miles per hour or greater from causing visible dust emissions

The maintained landscaping will comply with this potential ARAR.

Excavation and Off-Site Disposal

The Navy has identified the substantive provisions of the following potential federal and state ARARs for excavation and off-site disposal of soil and any other waste generated during implementation of the alternatives:

- RCRA hazardous waste identification requirements at Cal. Code Regs. tit. 22, §§ 66262.10(a) and 66262.11
- The requirement to analyze generated waste to determine if it is hazardous at Cal. Code Regs. tit. 22 § 66264.13(a) and (b)
- Temporary staging pile requirements at 40 CFR § 264.554(d)(1)(i) through (ii), (d)(2), (e), (f), (h), (i), (j), and (k)
- Toxic control measure for airborne asbestos during construction, grading, quarrying, and surface mining operations at Cal. Code Regs. tit. 17, § 93105
- Clean Water Act storm water discharge requirements for construction that will disturb 1 or more acres at 40 CFR §§ 122.44(k)(2) and (4)
- Clean Air Act requirement that source emissions not equal or exceed 20 percent opacity under Bay Area Air Quality Management District (BAAQMD) Regulation 6-302
- The requirement to accurately characterize wastes under Cal. Code Regs. tit. 27 § 20200(c)
- The discharge requirements for designated waste to Class I or Class II waste management units at Cal. Code Regs. tit. 27 § 20210
- The discharge requirements for nonhazardous solid to classified units at Cal. Code Regs. tit. 27 §§ 20220(b), (c), and (d)

Any hazardous substance, pollutant, or contaminant that is shipped off site as a result of the implementation of this alternative will be shipped to a facility in compliance with 42 U.S.C. § 9621(d)(3) and EPA's off-site rule at 40 CFR § 300.440.

Constructing the Shoreline Revetment and Covers for the Soil

The Navy has identified the substantive provisions of the following potential federal and state action-specific ARARs for construction of the shoreline revetment and for construction of a soil, asphalt, or concrete cover for the soil:

- Final cover requirement to accommodate lateral and vertical shear forces generated by the maximum credible earthquake at Cal. Code Regs. tit. 22, § 66264.310(a)(5)
- Final cover maintenance requirements and final cover runon and runoff controls contained in Cal. Code Regs. tit. 22, § 66264.310(b)(1) and (4)
- Survey benchmark maintenance required in Cal. Code Regs. tit. 22, § 66264.310(b)(5)
- The requirement that source emissions not equal or exceed 20 percent opacity under the Clean Air Act, BAAQMD Regulation 6-302
- The allowance for engineered alternatives to the prescriptive final cover standards under Cal. Code Regs. tit. 27, § 20080(b)
- The requirement that public agencies comply with Cal. Code Regs. tit. 27 to the extent feasible when taking action to clean up unauthorized releases, at Cal. Code Regs. tit. 27, § 20090(d)
- Permanent monument requirements at Cal. Code Regs. tit. 27, § 20950(d)
- Final grading and maintenance requirements at Cal. Code Regs. tit. 27 § 21090(b)(1)
- Erosion and related damage prevention requirements at Cal. Code Regs. tit. 27, § 21090(c)(4)
- Aerial photographic survey, or alternative survey, requirements at Cal. Code Regs. tit. 27, § 21090(e)(1) and (3)
- Final cover and alternative final cover standards at Cal. Code Regs. tit. 27, § 21140
- Final slopes requirements at Cal. Code Regs. tit. 27, § 21145(a)
- Drainage and erosion control system requirements at Cal. Code Regs. tit. 27, § 21150

- Toxic control measure for airborne asbestos during construction, grading, quarrying, and surface mining operations at Cal. Code Regs. tit. 17, § 93105

- Clean Water Act storm water discharge requirements for construction that will disturb 1 or more acres at 40 CFR §§ 122.44(k)(2) and (4)

Construction of a Shoreline Revetment (Only)

The Navy has identified the substantive provisions of the following potential action-specific ARARs that apply only to construction of the shoreline revetment:

- RCRA temporary tank requirements for temporary storage of dredged material at Cal. Code Regs. tit. 22, § 66264.553(b), (d), (e), and (f)

- Dredge and fill requirements of the Clean Water Act § 404 (33 U.S.C. § 1344, 33 CFR §§ 320.4 and 323, 40 CFR §§ 230.10; 230.11; 230.20 through 230.25; 230.31; 230.32; 230.41; 230.42; and 230.53) related to construction along the shoreline

Soil Vapor Extraction

The Navy has identified the substantive provisions of the following potential federal ARARs:

- The requirement to use the best available control technology for new emission sources contained in San Francisco BAAQMD Regulation 2-1-301

- The requirements for SVE systems contained in BAAQMD Regulation 8-47

4.2.3.2 Potential Action-Specific ARARs for Groundwater Alternatives

Remedial alternatives evaluated for Parcel B groundwater include the following types of actions: (1) no action, (2) long-term groundwater monitoring and institutional controls, (3) *in situ* treatment and institutional controls as discussed in more detail in Section 5.0. The potential action-specific ARARs for these processes are discussed below.

Groundwater Monitoring

The Navy has identified the substantive provisions of the following potential federal and state ARARs for groundwater monitoring:

- The requirement to implement a corrective action monitoring program that demonstrates the effectiveness of the corrective action program, at Cal. Code Regs. tit. 22, § 66264.100(d)

- Constituents of concern requirements identified in Cal. Code Regs. tit. 22 § 66264.93

- The requirement to establish a sufficient number of monitoring points, at Cal. Code Regs. tit. 22 § 66264.97(b)(1)(A) and (b)(1)(D)(1) and (2)

- Monitoring well construction requirements at Cal. Code Regs. tit. 22 § 66264.97(b)(4), (5), (6), and (7)

- Sample collection requirements at Cal. Code Regs. tit. 22 § 66264.97(e)(6), (e)(12)(A)(3), (e)(12)(B), (e)(13), and (e)(15)

- The requirement that public agencies comply with Cal. Code Regs. tit. 27 to the extent feasible when taking action to clean up unauthorized releases at Cal. Code Regs. tit. 27 § 20090(d)

The Navy has identified the substantive provisions of the following potential federal and state ARARs for off-site disposal of investigation-derived waste generated during implementation of the alternatives:

- RCRA hazardous waste identification requirements at Cal. Code Regs. tit. 22, §§ 66262.10(a) and 66262.11

- The requirement to analyze generated waste to determine if it is hazardous at Cal. Code Regs. tit. 22 § 66264.13(a) and (b)

- The requirement to accurately characterize wastes under Cal. Code Regs. tit. 27 § 20200(c)

- The discharge requirements for designated waste to Class I or Class II waste management units at Cal. Code Regs. tit. 27 § 20210

- The discharge requirements for nonhazardous solid to classified units at Cal. Code Regs. tit. 27 §§ 20220(b), (c), and (d)

In Situ Treatment

Under this alternative, the Navy will inject substrates into groundwater to actively treat contaminants where concentrations are highest.

The Navy has identified the substantive provisions of the following potential federal action-specific ARAR:

- Requirement to prohibit constructing, operating, maintaining, converting, plugging, abandoning, or conducting any other injection in a manner that allows movement of fluid containing any contaminant into underground sources of drinking water, at 40 CFR § 144.12 under the Underground Injection Control Program of the Safe Drinking Water Act

Institutional Controls

The Navy has identified the substantive provisions of the following potential state ARARs for the groundwater institutional controls as more fully described in Appendix C:

- California Civil Code § 1471 and California Health and Safety Code §§ 25202.5, 25222.1, 25232(b)(1)(A)-(E), 25233(c), 25234, and 25355.5(a)(1)(C) and Cal. Code Regs. tit. 22 § 67391.1

4.3 GENERAL RESPONSE ACTIONS AND PROCESS OPTIONS ANALYSES

GRAs are categories of actions that are made up of specific process options. These GRAs are responses or remedies that will meet the RAOs to protect human health and the environment from the known contamination at Parcel B. Process options are specific technologies used to carry out a GRA. Section 4.3.1 describes the GRAs for Parcel B soil and groundwater, and Section 4.3.2 presents the results of the analysis for the proposed GRAs. As in Section 4.2, options related to remediation of sediment and soil gas are discussed together with the other options for soil because of the similarity of the actions and technologies.

4.3.1 Development of General Response Actions

GRAs were derived from engineering judgment and experience with remedial actions proven successful for the COCs at Parcel B. Because the RAOs were developed based on the planned future land use, the GRAs were also developed considering the planned future land use of each redevelopment block. The GRAs and the process options for Parcel B are presented in Table 4-1 for soil and in Table 4-2 for groundwater. The following GRAs were identified to ensure that the RAOs for soil and groundwater are met.

Soil

- No action – Required GRA for CERCLA evaluation
- Institutional controls – Includes land-use restrictions and access restrictions
- Removal – Includes excavating and off-site disposal of excavated soil

- Treatment – Includes *in situ* and *ex situ* treatment of soil to reduce the toxicity and volume of the contaminants

- Containment – Includes covering contaminated soil and sediment to break the direct exposure pathway

Groundwater

- No action – Required GRA for CERCLA evaluation

- Institutional controls – Includes land-use restrictions and access restrictions

- Treatment – Includes *in situ* and *ex situ* treatment of contaminated groundwater

- Removal – Includes pumping to remove the groundwater before disposal

- Containment– Includes installing a slurry wall to control groundwater flow and vapor controls to prevent vapor intrusion

Process options for these GRAs are evaluated below in Section 4.3.2.

4.3.2 Analysis of General Response Actions and Process Options

GRAs selected for this TMSRA underwent an initial screening and a subsequent detailed analysis. During the initial screening, the range of technology types and process options are evaluated in terms of technical implementability, site conditions, waste characteristics, contaminant properties, and the ability to meet NCP requirements and RAOs. The results of the initial screening are summarized in Tables 4-1 and 4-2 for soil and groundwater. The GRAs and process options that were carried forward from the initial screening are then analyzed in terms of effectiveness, implementability, and cost. Table 4-3 summarizes the results of this detailed analysis. The screening and analysis of GRAs and process options is presented separately for soil and groundwater. Section 4.3.2.1 presents the analysis for the applicable process options for soil, and Section 4.3.2.2 presents the analysis for the applicable process options for groundwater.

4.3.2.1 Evaluation of Applicable Soil Process Options

Potentially applicable GRAs identified for soil at Parcel B consist of (1) no action, (2) institutional controls, (3) removal, (4) treatment, and (5) containment. The initial screening of process options for the remedial technology types for these GRAs is shown in Table 4-1. This table presents the various technology types, process options, and results of the screening analysis for each GRA for soil. The rationale for those options eliminated from further evaluation is presented in Table 4-1; these options are not discussed further.

All five GRAs are retained for further evaluation, including no action. The majority of the GRAs for treatment were eliminated during the initial screening of process options for soil at Parcel B; only soil vapor extraction was retained for evaluation. Several treatment options were considered for the COCs in soil. However, none of the treatment options is implementable for the ubiquitous metals that are present in fill at Parcel B at concentrations above remediation goals. Treatment is not as cost-effective or as implementable as excavation for the relatively small volumes associated with the remaining COCs.

Those process options retained during the initial screening were evaluated for effectiveness, implementability, and cost, and are discussed in this section. Table 4-3 summarizes the results for this evaluation.

No Action

The NCP requires that the no-action alternative be carried through the detailed analysis of alternatives. Under the no-action response, no remedial action is taken. Soil would be left as is without implementing any institutional controls, containment, removal, treatment, or other mitigating actions. Because soil at Parcel B poses a risk to human health and the environment under the anticipated future land-use scenario, the no-action response would not be an effective alternative that meets the requirements of CERCLA. No cost is associated with this option because no action is taken. The no-action option will be retained for further evaluation as a remedial alternative for comparison only, as required under the NCP.

Institutional Controls in General

Institutional controls are legal and administrative mechanisms used to implement land use and access restrictions that are used to limit the exposure of future landowner(s) and/or user(s) of the property to hazardous substances present on the property, and to ensure the integrity of the remedial action. Institutional controls are required on a property where the selected remedial cleanup levels result in contamination remaining at the property above levels that allow for unlimited use and unrestricted exposure. Institutional controls would likely remain in place unless the remedial action taken would allow for unrestricted use of the property. Implementation of institutional controls includes requirements for monitoring and inspections and reporting to ensure compliance with land use or activity restrictions.

Legal mechanisms include proprietary controls such as restrictive covenants, negative easements, equitable servitudes, and deed notices. Administrative mechanisms include notices, adopted local land use plans and ordinances, construction permitting, or other existing land use management systems that are intended to ensure compliance with land use or activity restrictions.

The Navy has determined that it will rely upon proprietary controls in the form of environmental restrictive covenants as provided in the "Memorandum of Agreement Between the United States Department of the Navy and the California Department of Toxic Substances Control" and attached covenant models (Navy and DTSC 2000) (hereinafter referred to as "Navy/DTSC MOA"). Appendix G contains the Navy/DTSC MOA.

More specifically, land use and activity restrictions will be incorporated into two separate legal instruments as provided in the Navy/DTSC MOA:

1. Restrictive covenants included in one or more Quitclaim Deeds from the Navy to the property recipient.

2. Restrictive covenants included in one or more "Covenant to Restrict Use of Property" entered into by the Navy and DTSC as provided in the Navy/DTSC MOA and consistent with the substantive provisions of Cal. Code Regs. tit. 22 § 67391.1.

The "Covenant(s) to Restrict Use of Property" will incorporate the land use restrictions into environmental restrictive covenants that run with the land and that are enforceable by DTSC against future transferees. The Quitclaim Deed(s) will include the identical land use and activity restrictions in environmental restrictive covenants that run with the land and that will be enforceable by the Navy against future transferees.

The activity restrictions in the "Covenant(s) to Restrict Use of Property" and Quitclaim Deed(s) shall be implemented through the Parcel B Risk Management Plan ("Parcel B RMP") to be prepared by the City of San Francisco and approved by the Navy and FFA Signatories. The Parcel B RMP shall be discussed in the Parcel B ROD amendment and shall be attached to and incorporated by reference into the "Covenant(s) to Restrict Use of Property" and Quitclaim Deed(s) as an enforceable part thereof. It shall specify soil and groundwater management procedures for compliance with the remedy selected in the Parcel B ROD amendment. The Parcel B RMP shall identify the roles of local, state, and federal government in administering the Parcel B RMP and shall include, but not be limited to, procedures for any necessary sampling and analysis requirements, worker health and safety requirements, and any necessary site-specific construction and/or use approvals that may be required.

In addition to being set forth in the "Covenant(s) to Restrict Use of Property" and Quitclaim Deed(s) as described above, restrictions applied to specified portions of the property will be described in findings of suitability for transfer and findings of suitability for early transfer.

<u>Access</u>

The Quitclaim Deed(s) and "Covenant(s) to Restrict Use of Property" shall provide that the Navy and FFA Signatories and their authorized agents, employees, contractors and subcontractors shall have the right to enter upon HPS Parcel B to conduct investigations, tests, or surveys; inspect field activities; or construct, operate, and maintain any response or remedial action as required or necessary under the cleanup program, including but not limited to monitoring wells, pumping wells, treatment facilities, and cap/containment systems.

Implementation

The Navy shall address and describe institutional control implementation and maintenance actions including periodic inspections and reporting requirements in the preliminary and final RD reports to be developed and submitted to the FFA Signatories for review pursuant to the FFA (see "Navy Principles and Procedures for Specifying, Monitoring and Enforcement of Land Use Controls and Other Post-ROD Actions" attached to January 16, 2004, DoD memorandum titled "Comprehensive Environmental Response, Compensation and Liability Act [CERCLA] Record of Decision [ROD] and Post-ROD Policy"). The preliminary and final RD reports are primary documents as provided in Section 7.3 of the FFA.

Activity Restrictions that Apply Throughout Parcel B

The following sections describe the institutional control objectives to be achieved through activity restrictions throughout Parcel B in order to ensure that any necessary measures to protect human health and the environment and the integrity of the remedy have been undertaken.

Restricted Activities

The following restricted activities throughout HPS Parcel B must be conducted in accordance with the "Covenant(s) to Restrict Use of Property," Quitclaim Deed(s), and the Parcel B RMP, and, if required, any other work plan or document approved in accordance with these referenced documents:

a. "Land disturbing activity" which includes but is not limited to: (1) excavation of soil, (2) construction of roads, utilities, facilities, structures, and appurtenances of any kind, (3) demolition or removal of "hardscape" (for example, concrete roadways, parking lots, foundations, and sidewalks), (4) any activity that involves movement of soil to the surface from below the surface of the land, and (5) any other activity that causes or facilitates the movement of known contaminated groundwater.

b. Alteration, disturbance, or removal of any component of a response or cleanup action (including but not limited to pump-and-treat facilities, revetment walls and shoreline protection, and soil cap/containment systems); groundwater extraction, injection, and monitoring wells and associated piping and equipment; or associated utilities.

c. Extraction of groundwater and installation of new groundwater wells.

d. Removal of or damage to security features (for example, locks on monitoring wells, survey monuments, fencing, signs, or monitoring equipment and associated pipelines and appurtenances).

Prohibited Activities

The following activities are prohibited throughout HPS Parcel B:

a. Growing vegetables or fruits in native soil for human consumption.
b. Use of groundwater.

Activity Restrictions Relating to VOC Vapors at Specific Locations within Parcel B

Any proposed construction of enclosed structures must be approved in accordance with the "Covenant to Restrict Use of the Property," Quitclaim Deed, and Parcel B RMP prior to the conduct of such activity within the area requiring institutional controls (ARIC) for VOC vapors in order to ensure that the risks of potential exposures to VOC vapors are reduced to acceptable levels that are adequately protective of human health. Initially, the ARIC will include all of Parcel B except Redevelopment Block 4. This can be achieved through engineering controls or other design alternatives that meet the specifications set forth in the ROD amendment, RD reports, land use control remedial design (LUC RD) report, and Parcel B RMP. The ARIC may be modified by the FFA Signatories as the soil contamination areas and groundwater contaminant plumes that are producing unacceptable vapor inhalation risks are reduced over time or in response to further soil, vapor, and groundwater sampling and analysis for VOCs that establishes that areas now included in the ARIC do not pose unacceptable potential exposure risk to VOC vapors.

Additional Land Use Restrictions for IR Sites 7 and 18

The following restricted land uses for property in IR Sites 7 and 18 must be reviewed and approved by the FFA Signatories in accordance with the "Covenant(s) to Restrict Use of the Property," Quitclaim Deed(s), and Parcel B RMP prior to use of the property for any of the restricted uses:

a. A residence, including any mobile home or factory-built housing, constructed or installed for use as residential human habitation,

b. A hospital for humans,

c. A school for persons under 21 years of age, or

d. A day care facility for children.

Figure 4-3 presents the ARICs for Parcel B. The process options related to institutional controls will be retained for development and evaluation of remedial alternatives.

Access Restrictions

Access restrictions will include physical barriers such as fences and informational devices such as warning signs. Fences would be installed around the perimeter of the site to restrict public access. Signs warning of the presence and potential danger of hazardous materials would be posted on the fence to further discourage unauthorized access.

Removal

Removal is an effective process option for all contaminant groups associated with soil at Parcel B and involves removing and transporting contaminated material off site to a permitted treatment and disposal facility. Some pretreatment such as stabilization may be required or preferred to meet land disposal restrictions so that the most economical disposal option can be applied. Important considerations with the removal and disposal process option include excavation volume, fugitive emissions, hauling distance, and type of treatment and disposal facility for final deposition. Excavations will be to a maximum depth of 10 feet for research and development and mixed-use reuse (residential exposure) and educational/cultural reuse (industrial exposure) and to a maximum depth of 2 feet for open space land use (recreational exposure) except for source removal excavations, which may extend deeper than 10 feet bgs. The excavation for methane source removal may extend below 10 feet bgs depending on the location of the source material; the excavation for mercury source removal will extend below 10 feet bgs to the top of bedrock. The excavation cleanup criteria would be specific to the reuse type and analyte-specific remediation goals specified in Section 4.1.1.1.

Excavation is effective and implementable for many of the COCs found in soil at Parcel B. Most of the near-surface soil at Parcel B is fill that was placed without documentation. The mineral content in the fill, the locations where the fill was placed, the method of placement, and the concentrations of metals in the fill are not documented. As a result, metals at concentrations above remediation goals (such as arsenic and manganese) are spread throughout Parcel B. Excavation is not practical to address removal of these ubiquitous metals at concentrations above remediation goals. Excavation of ubiquitous metals could involve excavating most of Parcel B to 10 feet. Excavation is implementable in the case of lead, which is detected frequently above the HPAL but infrequently above the remediation goal. In addition, these higher concentrations are more likely associated with spills or releases. Excavation of organic compounds, which are assumed to be associated with releases, is an effective approach to reach RAOs for areas outside of buildings. Excavation is expected to be effective in removing whatever materials are present in the subsurface at Redevelopment Block 3 that are the source of the methane observed in soil gas samples. The source of methane is believed to be disposal of construction debris, possibly wood that is in contact with groundwater. Excavation depths in this area may exceed 10 feet to remove all methane source materials. However, the depth to bedrock in the area of the methane source is anticipated to be about 15 to 20 feet bgs.

Likewise, excavation is expected to be effective in removing mercury source material present beneath former Excavation EE-05. The maximum depth of mercury source removal will be to bedrock (expected at about 15 feet bgs) or to the maximum depth practicable. The horizontal extent of mercury in soil was delineated to the ROD cleanup goal for mercury (the HPAL) during the remedial action. This delineation will provide the horizontal extent for the mercury source removal. Excavation at depths significantly below the groundwater level will be difficult because of dewatering considerations and may not be feasible because of the immediate proximity of the bay. Cone penetrometer tests or soil borings may be required to locate the depth of the bedrock in this area; the RD will specify the depth of the excavation. The excavation for removal of the mercury source will extend to bedrock unless local site conditions (for example, excessive groundwater infiltration) prevent completion to bedrock. The costs for removal of mercury source material are expected to be moderate.

Excavation would be more difficult for areas along the shoreline of Parcel B. The saturated nature of the sediment and the immediate proximity of the bay are added challenges to excavation along the shoreline. In addition, the location and depth of the sediments as well as the location of contaminants within the sediments along the shoreline that may require remediation are not known in sufficient detail to remove them by excavation. These added difficulties make excavation along the shoreline a less attractive option. Therefore, the excavation process option will be retained for only the land-based areas contaminated by mercury, lead, or organic compounds (including the methane source area) that present potential unacceptable risk.

Five excavations would be required at Parcel B, and costs are expected to be moderate. The excavation, methane and mercury source removals, and off-site disposal process options will be retained for development and evaluation of remedial alternatives.

Removal of methane by venting the subsurface soil can also be an effective process option. Venting may include passive systems (for example, built into the design of a new structure) or active systems (such as induced vacuum systems using blowers). Methane venting will be retained for development and evaluation of remedial alternatives as a contingency in the event that (1) excavation of the methane source area does not adequately control the methane emissions or (2) excavation is infeasible based on site conditions (for example, if methane is produced from organic material in the native sediments instead of from identifiable construction debris).

Treatment

Treatment processes directly reduce the toxicity, mobility, or volume of contaminants. SVE is widely recognized as an effective technology for removal of VOCs from unsaturated soil. Pilot testing of SVE at Building 123 has shown this process option to be effective for reducing the mass of VOCs in soil. This process option would include expansion and continued operation of the pilot-scale SVE system that was operated at Redevelopment Block 8 (Building 123). Treatment of the extracted VOCs using granular activated carbon is also a proven technology that was employed on the pilot-scale system and would be continued as part of this process option. The pilot tests of SVE at Building 123 have shown that this technology is effective, implementable, and of moderate cost. Consequently, the SVE process option will be retained for development and evaluation of remedial alternatives.

Containment

Containment processes are intended to isolate the contaminated soil or sediment to prevent direct exposure and contaminant migration. The most appropriate containment process options for soil at Parcel B are surface covers. Cover materials used to prevent direct exposure may include clean soil, asphalt, or concrete, and the material to be used will depend on the planned reuse associated with each redevelopment block.

The general approach for implementing soil covers includes:

- Existing asphalt and concrete surfaces and buildings will be considered existing covers so long as they block the exposure pathway from the soil to the potential surface receptors. Existing asphalt can be renovated with an asphalt seal coat, and concrete surfaces and building floors can be patched so long as the patches and seals adequately break the pathway. Rehabilitation of existing covers will be designed to meet the same minimum requirements as new covers.

- Where covers are needed, areas will be covered with a durable material that will not break, erode, or deteriorate such that the underlying soil becomes exposed. Standard construction practices for roads, sidewalks, and buildings would likely be adequate to meet this performance standard. Other examples of covers could include a minimum 4 inches of asphalt or a minimum 2 feet of clean imported soil. All covers must achieve a full cover over the entire redevelopment block. The exact nature and specifications for covers can vary from block to block, but all covers must meet the performance standard of preventing exposure to soil and durability.

- Drainage for asphalt and concrete covers will be consistent with the adjacent existing covers. Drainage for soil covers will be engineered so as not to promote erosion.

- All existing or newly installed covers will need to be maintained. Maintenance includes inspections and repairs for covers that are left in place during the future land use and replacement of covers if the future land use requires excavation or demolition of the covers during construction. Any modification of existing hardscape will be subject to the institutional controls described earlier.

- Sampling requirements associated with disturbance of covers will be in accordance with the RMP.

The process option of covers is effective, so long as the covers are properly installed and maintained and are replaced after excavation or demolition during redevelopment. The implementability and cost of covers are expected to be moderate because they are already in place at most of the redevelopment blocks at Parcel B.

The most appropriate containment process option for sediment is a shoreline revetment. The revetment includes two key features that allow it to isolate contaminated sediment: (1) a geomembrane to prevent migration of fine-grained sediment into the bay, and (2) an erosion-control element such as riprap, gabions, articulated concrete mat, or concrete structure.

As described in Table 4-3, shoreline enhancement was eliminated from consideration based on the difficulty in installing a geomembrane along the IR-26 shoreline, where a large amount of riprap already exists. The geomembrane cannot be installed over the existing riprap. The process involved in removing the existing riprap and then installing the geomembrane is not significantly different from the shoreline revetment option, so the enhancement option was eliminated. The shoreline sheet-pile wall option was also eliminated based on high cost and potential corrosion of the sheet piles and subsequent high repair cost.

The shoreline revetment would be constructed to protect the entire shoreline for the redevelopment blocks where the revetment is necessary. Installation of the revetment will require some excavation to establish appropriate grades and to allow placement of erosion control materials at appropriate elevations relative to sea level. However, this excavation is only incidental as part of the construction and would not be intended to focus on removal of contaminants. The 1,300-ft^2 wetland at Redevelopment Block BOS-1 would be filled and the Navy would mitigate the loss of the wetland using either compensatory mitigation, mitigation banking, or an in-lieu fee arrangement. Similar to soil covers, the revetment will need to be maintained, inspected, and repaired, as needed. This process option is effective and has moderate implementability and cost.

The cover and the shoreline revetment process options will be retained for development and evaluation of remedial alternatives.

4.3.2.2 Evaluation of Applicable Groundwater Process Options

Potentially applicable GRAs identified for groundwater at Parcel B consist of (1) no action, (2) institutional controls, (3) monitoring, (4) treatment, (5) removal, and (6) containment. The initial screening of process options for the remedial technology types for these groundwater GRAs is shown in Table 4-2. This table presents the various technology types, process options, and results of the screening analysis for each groundwater process option. Removal and containment of groundwater were not retained after the initial screening based on difficulty of implementation and poor effectiveness. The rationale for the options eliminated from further evaluation is presented in Table 4-2; these options are not discussed further.

The process options retained during the initial screening are evaluated for effectiveness, implementability, and cost and are discussed in this section. Table 4-3 summarizes the results of this evaluation.

No Action

The NCP requires that the no-action alternative be carried through the detailed analysis of alternatives. Under the no-action response, no remedial action is taken. Groundwater would be left as is without implementation of any institutional controls, containment, removal, treatment, monitoring, or other mitigating actions. Groundwater at Parcel B poses a risk to human health and the environment based on the current HHRA, SLERA, and surface water quality screening evaluation. Therefore, the no-action response would not be an effective alternative that meets the requirements of CERCLA. No cost is associated with this option because no action is taken. The no-action option will be retained for further evaluation as a remedial alternative for comparison only, as required under the NCP.

Institutional Controls

As discussed under the evaluation of soil process options, the Navy will use proprietary controls in the form of environmental restrictive covenants as provided in the Navy/DTSC MOA (Navy and DTSC 2000).

Land use restrictions will be incorporated into and implemented through two separate legal instruments as provided in the Navy/DTSC MOA:

- Restrictive covenants included in one or more Quitclaim Deeds from the Navy to the property recipient.
- Restrictive covenants included in one or more "Covenant to Restrict Use of Property" entered into by the Navy and DTSC as provided in the Navy/DTSC MOA and consistent with the substantive provisions of Cal. Code Regs. tit. 22 § 67391.1.

As discussed under the evaluation of soil process options, the Navy and FFA Signatories and their authorized agents, employees, contractors and subcontractors shall have the right to enter upon HPS Parcel B to conduct investigations, tests, or surveys; inspect field activities; or construct, operate, and maintain any response or remedial action as required or necessary under the cleanup program, including but not limited to monitoring wells, pumping wells, treatment facilities, and cap/containment systems. The Navy shall address institutional control implementation and maintenance actions including periodic inspections and reporting requirements in the preliminary and final RD reports to be developed and submitted to the FFA Signatories for review pursuant to the FFA.

Land Use Restrictions

The land use restrictions, restricted activities, and prohibited activities discussed under the evaluation of soil process options in Section 4.3.2.1 include the groundwater restrictions that will be placed as institutional controls under the groundwater alternatives.

The process options related to institutional controls will be retained for development and evaluation of remedial alternatives.

Groundwater Monitoring

Groundwater monitoring is an effective process option for assessing changes in the concentrations of VOCs and metals (including chromium VI, copper, lead, and mercury). Groundwater monitoring can detect potential increases in concentrations or migration of contaminants that could increase the risk of exposure of humans or aquatic life in the bay. Reductions in concentrations of VOCs have been observed over time at Parcel B, most likely as the result of treatability studies (such as ZVI injection). Groundwater monitoring was a central component of the remedy for groundwater in the 1997 ROD. The monitoring option is easy to implement at relatively low cost. This option will be retained for development and evaluation of remedial alternatives.

Treatment

The contaminated groundwater at Parcel B that exceeds remediation goals is present only in the A-aquifer. VOCs are the only COCs for groundwater based on the human health risk; the exposure pathway is from vapor intrusion into indoor air. Metals (including chromium VI, copper, lead, and mercury) are also COCs for groundwater based on the potential for migration to surface water. Table 4-2 provides a first screening of multiple treatment technologies, resulting in two types of treatment technologies that are retained: (1) *in situ* biological treatment, and (2) *in situ* chemical treatment.

In Situ Biological Groundwater Treatment

The *in situ* biological treatment technology type consists of aerobic and anaerobic reaction process options in the aquifer that degrade the dissolved-phase organic contaminants to less toxic compounds. These *in situ* processes tend to be more economical than *ex situ* processes because no removal or handling of groundwater is required for these methods. *In situ* biodegradation is generally implemented by injecting into the contaminant plume a nutrient substrate that may be infused with microorganisms specific for degrading COCs. This process may also be implemented by injecting only a nutrient substrate to enhance the growth of naturally occurring microorganisms.

Under both aerobic and anaerobic process options, the microorganisms metabolize and mineralize the COCs into less toxic byproducts. Some organisms degrade specific compounds anaerobically, while others degrade compounds aerobically. *In situ* biological groundwater treatments are not effective for extremely high concentrations or separate-phase products of VOCs, but these processes are effective for moderate to low concentrations of VOCs found at Parcel B, assuming the optimal species and nutrients are applied.

Recent studies at HPS have demonstrated that aerobic bioremediation is effective for fuel-related products and for chlorobenzenes, as well as for the less-chlorinated VOCs (such as vinyl chloride) that are present at Parcel B (Shaw Environmental, Inc. 2005). Aerobic bioremediation is, therefore, retained for evaluation. A recent treatability study at Parcel C has demonstrated that native microorganisms are present in the A-aquifer that are capable of degrading VOCs using anaerobic processes (Shaw Environmental, Inc. 2005). Although it is not effective for mercury and may not be effective for other metals in groundwater, *in situ* biodegradation is effective for VOCs.

The *in situ* biological groundwater treatment process option is fairly easy to implement as a standard, proven technology, and has been found to be implementable at moderate costs. The major challenge to *in situ* groundwater treatment technology is to achieve effective mass transfer of the substrate throughout the treatment zone. The aerobic and anaerobic bioremediation process options will be retained for development and evaluation of remedial alternatives.

In Situ Chemical Groundwater Treatment

The *in situ* chemical groundwater treatment technology type consists of oxidation and reduction reaction process options in the aquifer either that degrade the dissolved-phase contaminants to less toxic compounds or that precipitate contaminants within the aquifer. As with *in situ* biological remediation, no removal or handling of groundwater is required. This factor tends to make these *in situ* processes more economical than the *ex situ* processes.

A reduction reaction would be most effective for the VOCs present at Parcel B. Chemical oxidation is not known to be effective for treating mercury (Ground-Water Remediation Technology Analysis Center 1999). Therefore, the oxidation reaction is eliminated and is not discussed further.

Chemical degradation through injection of reduction reagents is generally initiated by injecting reactive chemicals, such as ZVI or other compounds, to create a reduced condition in the aquifer. The injected reagents chemically degrade the contaminants into less toxic byproducts by dechlorinating the VOCs. These reactions usually stimulate biodegradation from naturally occurring microorganisms that further enhances the degradation of VOCs. This type of reaction is therefore effective for the VOCs found at Parcel B and would be effective at both high and low concentrations of these contaminants in groundwater. Remediation products are available that simultaneously remove dissolved metals from groundwater and immobilize them and also provide a substrate for biodegradation of chlorinated compounds. The use of a metals treatment substrate containing sulfur that is specifically designed to precipitate chromium VI will reduce chromium VI to chromium III, and will remove both from the dissolved phase (Willett and Kroenigsberg 2004). Other metals, such as copper, lead, and mercury, will also be immobilized from the dissolved phase. This type of process is effective for VOCs and metals found at Parcel B and would be effective at both moderate and low concentrations of these contaminants in groundwater.

The *in situ* groundwater treatment process option reduces the toxicity, mobility, and volume of hazardous substances in groundwater and satisfies the RAOs. These treatment process options are fairly easy to implement as a standard, proven technology. In addition, they have been evaluated to be implementable at moderate to high costs, depending on the type of additives used, the volume of additive needed, and the number of inoculations. As with bioremediation, achieving effective mass transfer of ZVI throughout the treatment zone is a key factor in the successful implementation of this technology. The reduction reaction process option will be retained for development and evaluation of remedial alternatives.

FIGURES

Hunters Point Shipyard, San Francisco, California

U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 4-2
COMPARISON OF THE 2004 GROUNDWATER PLUMES AND RISK PLUMES

TMSRA for Parcel B

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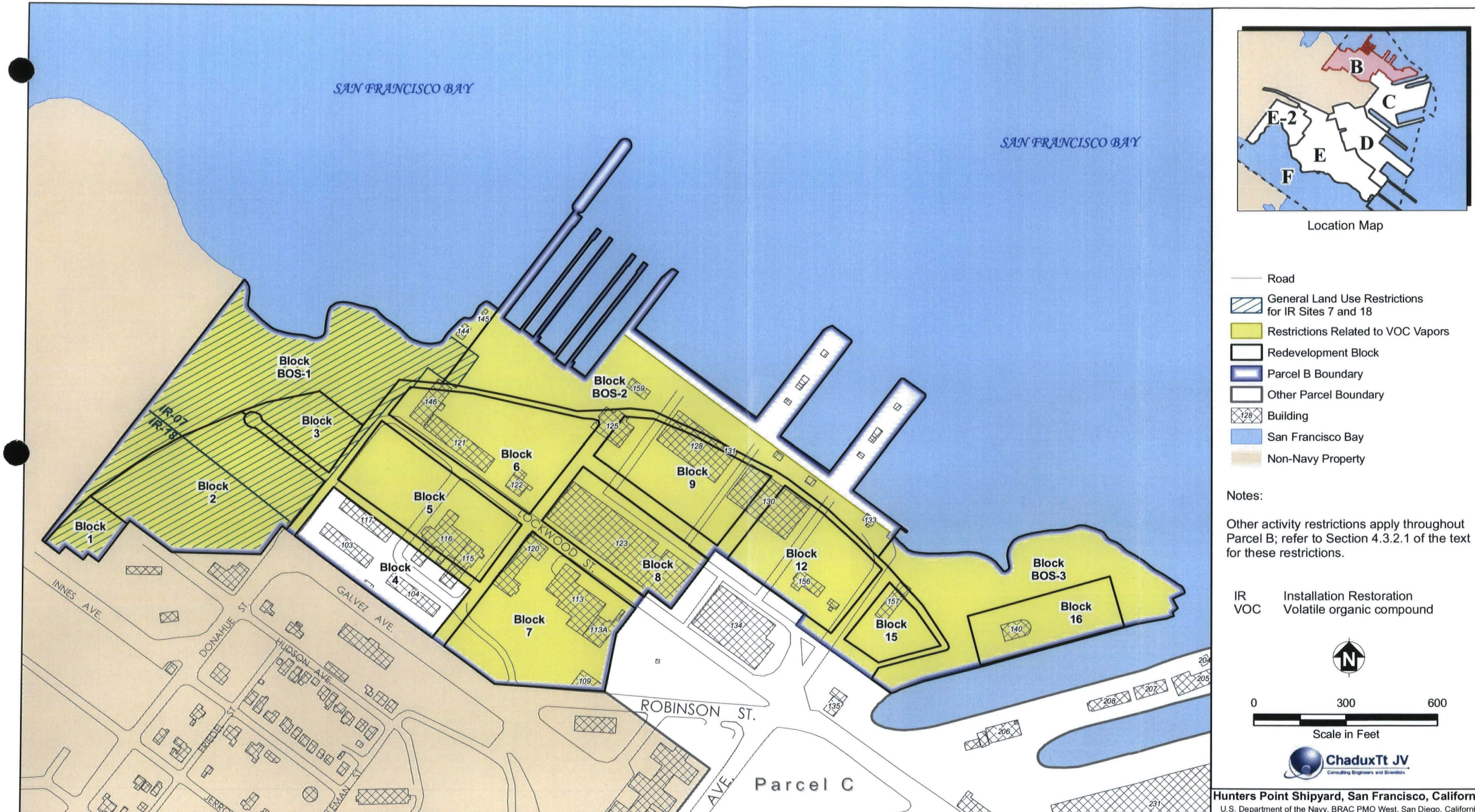

Hunters Point Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 4-3
PARCEL B
AREAS REQUIRING
INSTITUTIONAL CONTROLS

TMSRA for Parcel B

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TABLES

TABLE 4-1: SCREENING OF GENERAL RESPONSE ACTIONS AND PROCESS OPTIONS FOR SOIL

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
No Action	Not Applicable	Not Applicable	No Action	Retained – required by NCP
Access Restrictions	Engineering Controls	Barriers and Signs	Fencing, barriers, and posting signs to restrict land use where there is exposure to potentially contaminated soil (EPA 2000a).	Retained – easily implemented and effective; usually required to restrict activity based on land use.
Institutional Controls	Institutional Controls	Land Use Restrictions	Restricts activities not specified for the designated land use; prohibits growing produce in native soil (EPA 2000a).	Retained – easily implemented and effective; usually required to restrict activity based on land use.
		Covenants to Restrict Use of Property/Deed Restrictions	Restricts the use of the parcel using environmental restrictive covenants that will run with the land; includes criteria during and after future development to assure that mitigated exposure conditions are maintained such as covers, barriers, or other engineering controls (Navy and DTSC 2000).	Retained – easily implemented and effective; usually required to restrict activity based on land use.
Removal	Excavation	Conventional Excavation	Excavation of contaminants using conventional mechanical equipment; limited to maximum depth of 10 feet bgs (except for methane and mercury source removal where excavation will extend deeper for source removal).	Retained for excavation of soil where concentrations of organic compounds, lead, mercury, and methane above cleanup goals have been detected – effective; easily and quickly implemented (moderate for excavation below 10 feet bgs); permanent remedy; moderate cost. Eliminated for ubiquitous metals such as arsenic, iron, and manganese and the heterogeneous fill areas of IR-07 and IR-18 – not implementable or cost effective for entire redevelopment blocks.

TABLE 4-1: SCREENING OF GENERAL RESPONSE ACTIONS AND PROCESS OPTIONS FOR SOIL (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
Removal (cont.)	Methane Venting	Methane Venting	Venting of subsurface soil using passive or active systems where elevated concentrations of methane have been detected	Retained as a contingency if source removal is ineffective– effective; easily and quickly implemented; permanent remedy; moderate cost.
	Off-Site Disposal	Treatment/Disposal Facility	Transport and dispose of soils at a permitted treatment and disposal facility; includes excavated soil to remove COCs from the soil, and existing soil stockpiles that potentially contain COCs.	Retained – effective; easily and quickly implemented; permanent remedy; moderate cost.
Treatment	Biological Treatment	Bioremediation	Reduces contaminants from soil by metabolizing organic compounds with biological amendments (FRTR 2005)	Eliminated – not effective for metal COCs; not efficient for small volumes of soil with low concentrations of organic compounds.
	Physical/Chemical Treatment	Soil Washing	Remove contaminants by exposing soil to an aqueous washing solution in a reactor (FRTR 2005)	Eliminated – difficult to implement for heterogeneous soils; not implementable for ubiquitous metals or cost effective for entire redevelopment blocks.
		Solidification/Stabilization	Reduction of contaminant mobility through physical or chemical reaction with stabilizing agents (EPA 1998a)	Eliminated – mostly effective for mitigating metals mobility for the protection of groundwater, but not effective in reducing toxicity from the direct exposure to soils; not implementable for ubiquitous metals and heterogeneous soils; not effective for PAHs or PCBs.
		Chemical Oxidation	Conversion of inorganic contaminants to nonhazardous compounds using an oxidizing agent (EPA 1998b)	Eliminated – not effective for metal COCs in soil; not efficient for small volumes of soil with low concentrations of organic compounds.

TABLE 4-1: SCREENING OF GENERAL RESPONSE ACTIONS AND PROCESS OPTIONS FOR SOIL (CONTINUED)
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
Treatment (cont.)	Physical/Chemical Treatment (cont.)	Solvated Electron Process	Soil is treated by first mixing with liquid ammonia to form a soil/ammonia slurry; adding elemental calcium or sodium to the slurry; separating the ammonia from the soil as a liquid until most of the ammonia is removed and then as a vapor by warming the soil (FRTR 2005).	Eliminated – not applicable for metals; Highly exothermic reaction creates health and safety concerns; not cost effective for small volumes of soil with low concentrations of organic compounds; high cost.
		Soil Vapor Extraction	VOCs are extracted from the unsaturated zone using vacuum pumps; also used with active volatilization of VOCs from groundwater (EPA 1997b).	Retained; while not effective for metals, a treatability study at Parcel B indicates effectiveness of SVE for VOCs in soil gas above a chlorinated VOC groundwater plume.
Treatment (Continued)	Thermal Treatment	Incineration	Volatilization and combustion of soil contaminants (FRTR 2005)	Eliminated – not effective for metals; numerous regulatory requirements, low public acceptance, high cost.
		Low temperature thermal desorption	Volatilization of organic contaminants well below oxidation temperatures (FRTR 2005)	Eliminated – not effective for metals; high cost.
Containment	Covers	Soil Covers	Placement of a cover of "clean" soil over contaminated soil to eliminate the direct exposure pathway	Retained – effective for metal and organic COCs; easily and quickly implemented; moderate cost per area.
		Asphalt or Concrete Covers	Place an asphalt or concrete cover over contaminated soil to eliminate the direct exposure pathway (EPA 1998a)	Retained – effective for metal and organic COCs; easily and quickly implemented; moderate cost per area.
		Maintained Landscaping	Maintain a vegetative cover over contaminated soil to minimize wind erosion	Retained – effective for asbestos control; easily and quickly implemented; moderate cost per area.

TABLE 4-1: SCREENING OF GENERAL RESPONSE ACTIONS AND PROCESS OPTIONS FOR SOIL (CONTINUED)
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
Containment (cont.)	Covers (cont.)	Offshore Breakwater	Pervious dams of rocks supported by existing material, faced with large armor units and provided with a toe to initiate wave breaking.	Eliminated; while the breakwater would absorb the bulk of the wave energy and prevent erosion, soil would remain in contact with San Francisco Bay; small riprap armor still necessary.
		Shoreline Sheet-Pile Wall	Wall of corrosion-resistant sheet pile with riprap toe-erosion protection, driven into the shoreline and supported by sufficient pile depth and corrosion-resistant tiebacks.	Retained – effective for shoreline protection
		Shoreline Enhancement	Amend existing riprap along shoreline	Retained for areas along the shoreline with existing riprap
		Shoreline Revetment	Placement of an erosion-control structure consisting of riprap, large armor units, gabions, articulating concrete mats, or engineered concrete structures along the shoreline.	Retained – effective for shoreline protection

Notes: Shaded process options are eliminated for further evaluation as a remedial alternative

bgs	Below ground surface	PAH	Polynuclear aromatic hydrocarbon
COC	Chemical of concern	PCB	Polychlorinated biphenyl
DTSC	Department of Toxic Substances Control	ROD	Record of decision
EPA	U.S. Environmental Protection Agency	SVE	Soil vapor extraction
FRTR	Federal Remediation Technologies Roundtable	VOC	Volatile organic compound
NCP	National Oil and Hazardous Substances Pollution Contingency Plan		

<u>Sources</u>:

EPA. 1997a. "Best Management Practices (BMPs) for Soils Treatment Technologies." EPA 530-R-97-007. May.

EPA. 1997b. "Analysis of Selected Enhancements for Soil Vapor Extraction." EPA 542-R-97-007. September.

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TABLE 4-2: SCREENING OF GENERAL RESPONSE ACTIONS AND PROCESS OPTIONS FOR GROUNDWATER
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
No Action	Not Applicable	Not Applicable	No Action	Retained – required by NCP
Institutional Controls	Institutional Controls	Institutional Controls	Restricts subsurface intrusive activities that might result in, or facilitate, the movement of contaminated groundwater. Restricts alteration, disturbance, or removal of any component of a response or cleanup action, including security features. Restricts extraction of groundwater and installation of new groundwater wells. Restricts the use of the parcel using environmental restrictive covenants that will run with the land; includes criteria during and after future development to assure that mitigated exposure conditions are maintained such as vapor barriers or other engineering controls (Navy and DTSC 2000).	Retained – easily implemented and effective; prevents exposure to COCs.
Monitoring	Monitoring	Monitoring	Groundwater is sampled and analyzed for COCs; results are evaluated and reported to assess changes in concentrations and migration of the contaminants to potential exposure points (EPA 2004).	Retained – easily implemented; effective for all COCs; low cost.
Treatment	Passive	Natural Recovery	COCs are allowed to naturally attenuate via biodegradation, dispersion, dilution, or adsorption; Requires monitoring to assess recovery rates and success (IRTC 1999).	Retained – easily implemented; effective for all COCs at low concentrations; low cost; slow results.
	Ex Situ Pump and Treat	Chemical, physical, or biological treatment	Vertical or horizontal wells are pumped to extract contaminated groundwater from the saturated zone; extracted groundwater is treated through chemical, physical, or biological processes; treated water is released to the surface, to the surface water, or to a wastewater treatment plant or is reinjected (FRTR 2005).	Eliminated – effective for all COCs, but not effective at low concentrations (both VOCs and metals); may leave significant concentrations of COCs behind as the aquifer is dewatered; requires high level of effort to implement; high O&M cost; may have slow results.

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
Treatment (Continued)	*Ex Situ* Pump and Treat	Dual Phase Extraction	Vertical wells are pumped to extract contaminated groundwater, and are under negative pressure to extract volatile contaminants from the water surface, capillary fringe, and the vadose zone soils; extracted groundwater and vapors are treated through chemical, physical, or biological processes (EPA 1999b).	Eliminated – mostly effective for VOC COCs, but not effective for all COCs at low concentrations; not effective for metals; requires high level of effort to implement; high O&M cost; may have slow results.
	In Situ Biological Treatment	Aerobic and Anaerobic Bioremediation	Electron donors, electron acceptors, nutrients, and possibly microorganisms are injected into the contaminated groundwater to create or enhance aqueous biological activity that degrades the contaminants to less toxic or mineralized compounds; requires monitoring to assess remedial progress. (FRTR 2005).	Retained – effective for VOCs at moderate to low concentrations; easily implemented at moderate cost; no O&M cost; requires monitoring, but treatment should reduce long-term monitoring effort.
		Phytoremediation	Uses plant uptake to remove, transfer, stabilize, and destroy organic/inorganic chemicals in groundwater; Requires monitoring to assess remedial progress (Ground-Water Remediation Technology Analysis Center 1997b).	Eliminated – effective for VOC COCs at low concentrations; may not be implementable with planned reuse; requires preliminary studies to determine appropriate species and assess remedial effectiveness; moderate implementation cost; moderate to low O&M cost; requires monitoring; may have slow results.
	In Situ Physical/Chemical Treatment	Chemical Oxidation	Chemicals, such as hydrogen peroxide, potassium permanganate, or Fenton's reagent, are injected into the contaminated groundwater to enhance the oxidation state of the aquifer, chemically altering dissolved contaminants to less toxic compounds or precipitants; requires monitoring to assess remedial progress (EPA 1998b).	Retained – moderately effective for VOC COCs at Parcel B but most efficient at high COC concentrations; not effective for metals; implementable as a fast-reacting remedy; moderate implementation costs with no O&M; requires monitoring, but treatment should reduce long-term monitoring effort.

TABLE 4-2: SCREENING OF GENERAL RESPONSE ACTIONS AND PROCESS OPTIONS FOR GROUNDWATER (CONTINUED)
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
Treatment (Continued)	*In Situ* Physical/Chemical Treatment (Continued)	Chemical Reduction	Chemicals, such as zero-valent iron, are injected into the contaminated groundwater to enhance the reduction state of the aquifer; chemically altering dissolved contaminants to less toxic compounds or precipitants; requires monitoring to assess remedial progress (EPA 2000d).	Retained – highly effective for VOCs and chromium VI but most efficient at high COC concentrations; not effective for copper, lead, and mercury; implementable as a fast-reacting remedy; moderate success as pilot tests at HPS; moderate implementation costs with no O&M; requires monitoring, but treatment should reduce long-term monitoring effort.
		Electrokinetic Separation	Induced electronic current creates an acid front (low pH) at the anode and a base front (high pH) at the cathode; acidic conditions mobilize metal contaminants for transport and collection at the cathode; requires monitoring to assess remedial progress (Ground-Water Remediation Technology Analysis Center 1997a).	Eliminated – highly effective for metals but less effective for VOCs; requires subsequent disposal of collected COCs that may need additional treatment before disposal; reactions may form undesirable byproducts; high setup and O&M cost.
		Air Sparging with SVE	Air is injected into the aquifer to mobilize volatile COCs into the unsaturated vadose zone soil; VOCs are extracted from the soils with SVE system (FRTR 2005).	Eliminated – highly effective for VOC COCs at moderate to high concentrations but control of air distribution is difficult in heterogeneous materials at Parcel B; moderate level of effort to implement; implementation may conflict with planned reuse; high implementation and O&M cost, including disposal or surface treatment.
		Ozone Sparging with SVE	Ozone is injected into the aquifer to mobilize volatile COCs into the unsaturated vadose zone soil and create a highly oxygenized environment; mobilized COCs are extracted from the soils with SVE system, and oxygenized groundwater chemically degrades COCs (EPA 1998b).	Eliminated – moderately effective for VOCs at moderate to high concentrations; implementation may conflict with planned reuse; high implementation and O&M cost, including disposal or surface treatment.

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
Treatment (Continued)	*In Situ* Physical/Chemical Treatment (Continued)	Permeable Reactive Barriers	Passive or reactive treatment walls are installed across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall; these walls allow the water to pass while prohibiting movement of contaminants by employing agents such as zero-valent metals, chelators (ligands selected for their specificity for a metal), sorbents, microbes, and others; the contaminants will either be degraded or retained in a concentrated form by the barrier material; requires monitoring to assess remedial effectiveness (EPA 1998c).	Eliminated – high level of effort to implement; a passive treatment wall would treat only water that moves through the wall, but not the source area; may have slow results based on groundwater gradients at HPS; ineffective where preferential pathways exist; implementation may conflict with planned reuse; limited field data concerning the longevity of wall reactivity or loss or permeability through precipitation (EPA 2000b); would not mitigate the vapor intrusion pathway risk; high implementation and O&M cost.
Removal	Pump and Dispose	Pumping	Large volumes of groundwater are pumped from the aquifer to capture the contaminated plume; extracted groundwater is either released to a wastewater disposal facility or is hauled off site for disposal (FRTR 2005).	Eliminated – effective for all COCs; not effective in heterogeneous or tight lithologic conditions; may leave significant concentrations of COCs behind as the aquifer is dewatered; high level of effort to implement; high implementation and O&M cost; potentially high cost for disposal.
Containment	Slurry Wall	Low-Permeability Wall	Install a low-permeability material, such as bentonite, in a trench or through well injections around the perimeter of the COC plume to stops groundwater flow and prevent migration of contaminants; requires monitoring to assess remedial effectiveness (EPA 1998a).	Eliminated – low effectiveness in obtaining a complete seal; may cause hydrogeologic problems such as a groundwater "mound"; would not mitigate the vapor intrusion pathway risk; high level of effort to implement, including permitting; implementation may conflict with planned reuse; high implementation and O&M cost.

TABLE 4-2: SCREENING OF GENERAL RESPONSE ACTIONS AND PROCESS OPTIONS FOR GROUNDWATER (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

General Response Action	Remedial Technology Type	Process Option	Description	Screening Comments
Containment (Continued)	Vapor Barriers	Epoxy Coating	The floor of the building is sealed with an epoxy-based sealant, providing a physical barrier to vapor migration into buildings.	Eliminated as stand-alone technology; poor performance record as it is difficult to ensure that all cracks are sealed and sealant itself cracks after time; may be used in conjunction with sub-slab depressurization to improve effectiveness.
		Sub-slab Depressurization	Blowers and vapor collection points are installed below the building to maintain a negative pressure gradient and prevent vapor intrusion.	Eliminated (retained for new construction only); although potentially low cost, an extensive investigation into the conditions under the building would be necessary to ensure that the systems are covering the entire foundation and that utility conduits and other preferential pathways are not present; otherwise, many systems would be required to provide effective negative pressure throughout the area beneath the building; retained for new construction as effective and low-cost method to minimize vapor intrusion.
		Raised-floor System	A new floor is installed above the building slab foundation and a depressurization system is installed between the floors to maintain a negative pressure gradient and prevent vapor intrusion.	Eliminated – expensive; reduces the functionality of the structure.

Notes:	Shaded process options are eliminated for further evaluation as a remedial alternative.
COC	Chemical of concern
DTSC	Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
FRTR	Federal Remediation Technologies Roundtable
HHRA	Human health risk assessment
HPS	Hunters Point Shipyard
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
O&M	Operation and maintenance
RAO	Remedial action objective
SVE	Soil vapor extraction
VOC	Volatile organic compound

Sources:

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EPA. 1998b. "Field Applications of In Situ Remediation Technologies: Chemical Oxidation." EPA 542-R-98_008. September.

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TABLE 4-3: ANALYSIS OF GENERAL RESPONSE ACTIONS AND PROCESS OPTIONS FOR SOIL AND GROUNDWATER
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

General Response Action	Remedial Technology Type	Process Option	Description	Effectiveness	Implementability	Cost	Screening Comments
				SOIL			
No Action	Not Applicable	Not Applicable	No Action	Does not achieve remedial action objectives	Not acceptable to local government or public	None	Retained, required by NCP.
Access Restrictions	Engineering Controls	Barriers and Signs	Fencing, barriers, and posting signs to restrict land use where there is exposure to potentially contaminated soil.	Effective at preventing exposure of human receptors to contamination, especially when used in combination with other options; does not prevent exposure of ecological receptors; does not reduce volume or toxicity of contamination (EPA 2000a).	Requires legal documents and authority to enforce restrictions. Easily implemented.	Low cost	Retained; easily implemented and effective; usually required to restrict activity based on land use; low cost.
Institutional Controls	Institutional Controls	Land Use Restrictions	Restricts activities not specified for the designated land use; prohibits growing produce in native soil.	Effective at preventing exposure of human receptors to contamination, especially when used in combination with other options; does not prevent exposure of ecological receptors; does not reduce volume or toxicity of contamination (EPA 2000a).	Requires legal documents and authority to enforce restrictions. Easily implemented.	Low cost	Retained; easily implemented and effective; not sufficient to prevent exposure alone, but effective in combination with engineering controls; low cost.
		Covenants to Restrict Use of Property/Deed Restrictions	Restricts the use of the parcel using environmental restrictive covenants that will run with the land; includes criteria during and after future development to assure that mitigated exposure conditions are maintained such as covers, barriers, or other engineering controls (Navy and DTSC 2000).	Effective at preventing exposure of human receptors to contamination, especially when used in combination with other options; does not prevent exposure of ecological receptors; does not reduce volume or toxicity of contamination (EPA 2000a).	Requires legal documents and authority to enforce restrictions. Easily implemented.	Low cost	Retained; easily implemented and effective; usually required to restrict activity based on land use; low cost.
Removal	Excavation	Conventional Excavation	Excavation of contaminants using conventional mechanical equipment	Effective at removing contamination and preventing long-term exposure to contamination; may expose workers and environment to contaminants during implementation; uses conventional construction methods; proven technology.	Easily implemented for defined areas of contamination; easily implemented for organic compounds (including methane source), mercury, and lead. Moderate for excavation below 10 feet bgs. Not implementable for ubiquitous metals such as arsenic, iron, and manganese because of the large areas involved; may need to excavate entire redevelopment blocks to 10 feet.	Moderate cost (based on previous excavations at Parcel B, includes confirmation sampling requirements).	Retained for organic compounds (including methane source), mercury, and lead; effective; easily implemented (moderate for excavation below 10 feet bgs); fast. Not retained for ubiquitous metals such as arsenic, iron, and manganese or the heterogeneous fill areas of IR-07 and IR-18.
	Methane Venting	Methane Venting	Venting of subsurface soil using passive or active systems where elevated concentrations of methane have been detected	Effective at removing contamination and preventing long-term exposure to contamination; may expose workers and environment to contaminants during implementation; uses conventional construction methods; proven technology.	Easily implemented for defined areas of contamination	Moderate cost	Retained for areas with elevated methane concentrations in soil gas (as a contingency if source removal is ineffective).

TABLE 4-3: ANALYSIS OF GENERAL RESPONSE ACTIONS AND PROCESS OPTIONS FOR SOIL AND GROUNDWATER (CONTINUED)
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

General Response Action	Remedial Technology Type	Process Option	Description	Effectiveness	Implementability	Cost	Screening Comments
				SOIL (Continued)			
Removal (Continued)	Off-Site Disposal	Treatment/Disposal Facility	Transport and dispose of soils at a permitted treatment and disposal facility	Effective at preventing exposure of receptors to contamination; does not reduce total amount of contamination; may expose workers and environment to contaminants during implementation; conventional method.	Requires appropriate transportation permits and waste characterization. Easily implemented.	High cost	Retained; effective; easily implemented; fast.
Treatment	Physical/Chemical Treatment	Soil Vapor Extraction	VOCs are extracted from unsaturated zone with vacuum pumps	EPA presumptive remedy for VOCs in unsaturated zone; pilot test at VOC plume under Building 123 indicates SVE is effective at removing chlorinated solvents from soil vapor; not effective for metals, so treatment area will be confined to areas at Building 123 that contain VOCs.	Off-gas treatment likely required by agencies; must meet local and state requirements for off-gas release; moderately implementable.	Low cost	Retained; while not effective for metals, the treatability study at Parcel B indicates the effectiveness of SVE for chlorinated VOCs in soil at Building 123.
Containment	Covers	Soil, Asphalt, or Concrete Cover	Place a soil, asphalt, or concrete cover over contaminated soil; prevents contact with contamination (EPA 1998a).	Effective at preventing exposure of receptors to contamination, must be used with land-use controls to maintain protectiveness, susceptible to weathering and cracking.	Paved areas can be easily maintained using conventional methods; soil or asphalt cover could be used in areas currently unpaved. Easily implemented.	Moderate cost	Retained for areas that are paved or require paving to achieve planned land uses, can be used with a soil cover.
		Maintained Landscaping	Maintain a vegetative cover over contaminated soil to minimize wind erosion	Effective at preventing exposure of receptors to contamination, must be used with land-use controls to maintain protectiveness, susceptible to erosion or severe weather conditions.	Easily maintained using conventional methods; easily implemented.	Moderate cost	Retained for areas that are currently bare or minimally vegetated soil that have been disturbed by excavation or construction activities and not restored with a cover of clean imported soil, asphalt, or concrete.
		Shoreline Sheet Pile Wall	Wall of corrosion-resistant sheet pile with rip rap toe-erosion protection, driven into the shoreline and supported by sufficient pile depth and corrosion-resistant tiebacks.	Effective at preventing erosion of contaminated soil into the bay; may expose workers and environment to contaminants during implementation; possibility of saltwater corrosion of sheet piles; requires specialized construction.	Moderate to difficult implementability because piles are driven through fill material; requires construction in waves and tides.	High cost	Eliminated; more difficult to implement than shoreline revetment; higher costs than shoreline revetment; if failure occurs, repair of the wall would be difficult and costly.
		Shoreline Enhancement	Amend existing rip rap along shoreline	Effective at preventing erosion of contaminated soil into the bay; existing rip rap may need to be removed to install protective measures, such as a geomembrane; may not be as effective as revetment; may expose workers and environment to contaminants during implementation.	Moderately implementable because of waves and tides	Moderate cost	Eliminated; the addition of more riprap to existing shoreline protection may not be as effective as revetment in preventing sediments from reaching the bay; a geomembrane cannot be installed over existing riprap, existing riprap would need to be removed.

TABLE 4-3: ANALYSIS OF GENERAL RESPONSE ACTIONS AND PROCESS OPTIONS FOR SOIL AND GROUNDWATER (CONTINUED)
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

General Response Action	Remedial Technology Type	Process Option	Description	Effectiveness	Implementability	Cost	Screening Comments
				SOIL (Continued)			
Containment (Continued)	Covers (Continued)	Shoreline Revetment	An erosion control structure consisting of rip rap, large armor units, gabions, articulating concrete mats, or engineered concrete structures is placed along the shoreline.	Effective at preventing erosion of contaminated soil into the bay; may expose workers and environment to contaminants during implementation.	Moderately implementable because of waves and tides	Moderate cost	Retained for areas along the shoreline
				GROUNDWATER			
No Action	Not Applicable	Not Applicable	No Action	Does not achieve remedial action objectives	Not acceptable to local government or public	None	Retained; required by NCP.
Institutional Controls	Institutional Controls	Engineering Controls	Restricts subsurface intrusive activities that might result in, or facilitate, the movement of contaminated groundwater. Restricts alteration, disturbance, or removal of any component of a response or cleanup action, including security features.	Effective at preventing exposure of human receptors to contamination, especially when used in combination with other options; does not prevent exposure of ecological receptors; does not reduce volume or toxicity of contamination (EPA 2000a).	Requires legal documents and authority to enforce restrictions. Easily implemented.	Low cost	Retained; effective, easy to implement, and low cost.
		Land Use Restrictions	Restricts extraction of groundwater and installation of new groundwater wells	Effective at preventing exposure of human receptors to contamination, especially when used in combination with other options; does not prevent exposure of ecological receptors; does not reduce volume or toxicity of contamination (EPA 2000a).	Requires legal documents and authority to enforce restrictions. Easily implemented.	Low cost	Retained; easily implemented and effective; not sufficient to prevent exposure alone, but effective in combination with engineering controls; low cost.
		Covenants to Restrict Use of Property/Deed Restrictions	Restricts the use of the parcel using environmental restrictive covenants that will run with the land; includes criteria during and after future development to assure that mitigated exposure conditions are maintained such as vapor barriers or other engineering controls (Navy and DTSC 2000).	Effective at preventing exposure of human receptors to contamination, especially when used in combination with other options; does not prevent exposure of ecological receptors; does not reduce volume or toxicity of contamination (EPA 2000a).	Requires legal documents and authority to enforce restrictions. Easily implemented.	Low cost	Retained; effective, easy to implement, and low cost.
Monitoring	Monitoring	Monitoring	Groundwater is sampled and analyzed for constituents identified for detection monitoring and evaluation monitoring programs; typically 30 years, although time can be reduced based on findings.	Does not achieve remedial action objectives; does not reduce the volume or toxicity of contamination (EPA 2004).	Easily implemented	Low cost	Retained; while monitoring does not achieve remedial action objectives on its own, long-term monitoring may be an important component of the other alternatives.
Treatment	Passive	Natural Recovery	Chlorinated hydrocarbons are allowed to naturally attenuate via biodegradation, dispersion, dilution, and adsorption (ITRC 1999). COCs are allowed to naturally attenuate via reduction, dispersion, dilution and adsorption. A monitoring program would be implemented to demonstrate the effectiveness of natural recovery.	Preliminary screening of analytical parameters indicates potential effectiveness of natural anaerobic biodegradation. At Parcel C, microorganisms were found to be present and very effective at reducing VOCs at HPS. Volume and toxicity of contamination is reduced; long treatment time.	Easily implemented	Low to moderate cost because of length of treatment time and sampling requirements	Retained as a contingency to supplement groundwater monitoring, as needed.

TABLE 4-3: ANALYSIS OF GENERAL RESPONSE ACTIONS AND PROCESS OPTIONS FOR SOIL AND GROUNDWATER (CONTINUED)
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

General Response Action	Remedial Technology Type	Process Option	Description	Effectiveness	Implementability	Cost	Screening Comments
GROUNDWATER (Continued)							
Treatment (Continued)	*In Situ* Biological Treatment	Aerobic Bioremediation	Additives including electron donors, electron acceptors, nutrients, and microorganisms, if necessary, are introduced to groundwater in areas where contaminants are present to enhance biodegradation of BTEX compounds, chlorobenzene, non-halogenated VOCs, and some halogenated VOCs (such as vinyl chloride).	Aerobic bioremediation is effective at reducing BTEX compounds and chorinated benzenes (EPA 2000d); volume and toxicity of contamination is reduced; not shown to be effective for TCE but can be effective for less halogenated VOCs such as vinyl chloride.	Easily implemented	Moderate cost	Retained for treatment of less halogenated VOCs such as vinyl chloride
		Anaerobic Bioremediation	Additives including electron donors, electron acceptors, nutrients, and sulfur-containing substrates (organosulfur compounds in a polylactate matrix such as lactate, molasses, vegetable oil, and cheese whey), and microorganisms, if necessary, are introduced to groundwater in areas where chlorinated solvents are present to enhance biodegradation of chlorinated VOCs.	Treatability study at a Parcel C at HPS indicates anaerobic bioremediation is effective at reducing chlorinated VOCs, including vinyl chloride. Treatability study injected lactate and hydrogen into the aquifer (Shaw Group 2005).	Easily implemented; substrates are not toxic.	Moderate cost	Retained; results from treatability study at Parcel C demonstrate effectiveness at reducing chlorinated VOCs including vinyl chloride, relies on biodegradation, no adverse impact to San Francisco Bay if amendments follow preferential pathways.
	In Situ Physical/Chemical Treatment	Chemical Oxidation	Chemicals (hydrogen peroxide, potassium permanganate, or Fenton reagent) are injected in the subsurface to enhance the oxidation of chlorinated VOCs and reduce chlorinated VOCs o nonhazardous or less toxic compounds that are more stable, less mobile, and inert (EPA 1998b).	Previous treatability study at Parcel C encountered preferential pathways and discharged to San Francisco Bay; effective at reducing the volume and toxicity of contamination; proven technology for VOCs; reactions (especially Fenton reagent) can produce heat that may affect utilities or off-gas that may accumulate in buildings.	Public acceptance may be difficult based on previous experience with chemical oxidation at Parcel C. Moderately implementable.	Moderate cost	Eliminated; potential for oxidant to follow preferential pathways which may result in areas of incomplete treatment or migration, potential for off-gas to accumulate under buildings; not effective for mercury and other metals of concern; higher cost than other alternatives.
		Chemical Reduction	ZVI is injected into an aquifer, which encourages enhanced reductive dechlorination of chlorinated VOCs.	Treatability study of ZVI injection at Parcel B resulted in substantial mass removal (ERRG and URS 2004) and appears to be effective on vinyl chloride based on recent groundwater monitoring results. Radius of influence at Parcel B was approximately 10 feet or less (ERRG and URS 2004) because lower injection pressures were necessary to minimize preferential pathways and daylighting of ZVI. Proven technology.	Implementable, regulatory agencies and public are familiar with the technology and the results of the pilot tests.	Moderate to high cost. Using same number of injection points as bioremediation, consumables cost is an order of magnitude more expensive than food sources for bioremediation; based on ZVI treatability studies at Parcels B and C.	Retained; mass removal is more than needed at Parcel B; effective for chlorinated VOCs (EPA 2000c).

TABLE 4-3: ANALYSIS OF GENERAL RESPONSE ACTIONS AND PROCESS OPTIONS FOR SOIL AND GROUNDWATER (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Notes:	Shaded process options are eliminated for further evaluation as a remedial alternative.
BTEX	Benzene, toluene, ethylbenzene, and xylenes
DTSC	Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
ERRG	Engineering/Remediation Resources Group, Inc.
HPS	Hunters Point Shipyard
ITRC	Interstate Technology and Regulatory Council
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
PAH	Polynuclear aromatic hydrocarbon
PCE	Tetrachloroethene
ROD	Record of decision
TCE	Trichloroethene
VOC	Volatile organic compound
ZVI	Zero-valent iron

Sources:

EPA. 1998a. "Evaluation of Subsurface Engineered Barriers at Waste Sites." EPA 542-R-98_005. August.

EPA. 1998b. "Field Applications of In Situ Remediation Technologies: Chemical Oxidation." EPA 542-R-98_008. September.

EPA. 2000a. The Office of Solid Waste and Emergency Response (OSWER) publication on Land Use Controls. Available Online at: http://www.epa.gov/oerrpage/superfund/action/ic/guide/index.htm

EPA. 2000c. "Engineered Approaches to In Situ Bioremediation of Chlorinated Solvents: Fundamentals and Field Applications" EPA 542-R-00_008. July.

EPA. 2000d. "In Situ Treatment of Soil and Groundwater Contaminated with Chromium" EPA/625/R-00/005. October.

EPA. 2004. "Demonstration of Two Long-Term Groundwater Monitoring Optimization Approaches." OSWER 5102G. EPA 542-R-04-001b. September.

ERRG and URS. 2004. "Cost and Performance Report Zero-Valent Iron Injection Treatability Study, Building 123, Parcel B, Hunters Point Shipyard, San Francisco, California."

ITRC. 1999. "Natural Attenuation of Chlorinated Solvents in Groundwater: Principles and Practices." September.

Navy and DTSC. 2000. "Memorandum of Agreement Between the United States Department of the Navy and the California Department of Toxic Substances Control." Use of model "Covenant to Restrict Use of Property" at installations being closed and transferred by the United States Department of the Navy.

Shaw Group. 2005. "In-Situ Anaerobic and Aerobic Bioremediation of a Mixed Chlorinated Organic Plume at the Hunters Point Shipyard, San Francisco, California." June 7.

Tetra Tech. 2003b. "Final Soil Vapor Extraction Confirmation Study Summary, Building 123, Installation Restoration Site 10, Parcel B, Hunters Point Shipyard, San Francisco, California." August 19.

Willett and Koenigsberg. 2004. "Cost Effective Groundwater Remediation, Selected Battelle Conference Papers 2003-2004."

5.0 DEVELOPMENT AND DESCRIPTION OF REMEDIAL ALTERNATIVES

This section presents potential remedial alternatives developed for soil and groundwater at Parcel B based on the general response actions and process options evaluated in Section 4.0. The NCP states that development and evaluation of remedial alternatives will reflect the scope and complexity of the remedial actions under consideration concerning the environmental issues defined at the site. The number and types of alternatives to be analyzed will be identified for each site by taking into account the scope and characteristics of the environmental issues at Parcel B. As in Section 4.0, alternatives related to remediation of sediment and soil gas are discussed together with the other alternatives for soil because of the similarity of the actions and technologies.

5.1 DEVELOPMENT OF REMEDIAL ALTERNATIVES

Process options were developed and screened as described in Section 4.0. The retained process options were combined into remedial alternatives to meet RAOs and to satisfy ARARs. The remedial alternatives were derived using experience and engineering judgment to formulate process options into the most plausible site-specific remedial actions.

The Navy's strategy for soil remedial alternatives is to remove the contaminated soils from the site by excavation and disposal wherever practical, to prevent exposure to soils that cannot be completely removed by eliminating complete exposure pathways to the receptors, or to treat soils contaminated with VOCs using SVE. Based on their location and extent (see Section 3.0), organic COCs (including the methane source), mercury, and lead in inland areas can be excavated, but other ubiquitous metals and COCs along the shoreline will require remedial actions that eliminate complete exposure pathways. Soil covers will eliminate exposure to potential unacceptable risk identified by the HHRA, and to potential unacceptable risk posed by ubiquitous metals likely present in locations that are not characterized by analytical data. Covers will use existing materials (rehabilitated as necessary) and newly installed materials to eliminate exposure. Various institutional controls are also integrated with each alternative to assure that the RAOs and ARARs are satisfied.

The Navy's strategy for groundwater remedial alternatives is to eliminate complete exposure pathways to the potential receptors and to monitor the known affected areas while the aquifer recovers. Process options intended to accelerate the natural recovery of the aquifer via *in situ* treatment are also considered. Various institutional controls are included in the remedial alternatives for groundwater to assure that the RAOs and ARARs are satisfied. Only the A-aquifer is considered for these remedial alternatives because no COCs exceeded remediation goals in the B-aquifer.

Both soil and groundwater remedial alternatives include five-year reviews to confirm that the remedies are continuing to protect human health and the environment. Costs for five-year reviews, as well as other long-term activities, are included in the cost estimates for all alternatives.

The alternatives developed for further analysis for both soil and groundwater are presented in the following sections.

5.1.1 Alternatives Developed for Soil

The alternatives developed for soil are summarized below.

Alternative S-1: No Action

For this alternative, no remedial action will be taken. Soil would be left in place without implementing any response actions. The no-action response is retained throughout the evaluation process as required by the NCP to provide a baseline for comparison with other alternatives.

Alternative S-2: Institutional Controls, Maintained Landscaping, and Shoreline Revetment

Alternative S-2 uses institutional controls, maintained landscaping, and constructing a shoreline revetment that, together, will meet all ARARs and RAOs. Institutional controls are described in detail in Section 4.3 and will be implemented parcel-wide for all of the redevelopment blocks to prevent exposure to potential unacceptable risks posed by COCs in soil. Institutional controls would require approved plans for construction that minimize risks to construction workers. Institutional controls will also prevent use of buildings over VOC plumes unless adequate measures are taken to prevent the exposure of residents to VOCs in soil or groundwater, possibly through the use of vapor barriers or other controls. An LUC RD will be prepared to identify specific implementation actions to ensure compliance with the institutional controls and to specify roles and responsibilities for implementing, monitoring, and enforcing the institutional controls.

Maintained landscaping will be required for areas that are currently bare or that are minimally vegetated soil that have been disturbed by excavation or construction and have not been restored with a cover (for example, clean imported soil, asphalt, or concrete). The maintained landscaping will prevent potential exposure to asbestos (that may be present in surface soil and transported by wind erosion) that would not be addressed by institutional controls alone.

The shoreline revetment would be constructed to eliminate exposure to contaminated shoreline sediment and to prevent migration of contaminated soil from inland locations to the bay. The revetment is intended to act as a barrier to erosion to prevent release of contaminated soil or sediment to the bay. The revetment would be constructed along the entire shoreline for each redevelopment block where the revetment is necessary. The 1,300-ft^2 wetland at Redevelopment Block BOS-1 would be filled and the Navy would mitigate the loss of the wetland using either compensatory mitigation, mitigation banking, or an in-lieu fee arrangement. Standard construction practices would be modified along the shoreline to minimize potential effects on the bay. These practices could include construction at low tide and using long-reach equipment. Knowledge the Navy gained during activities along the Parcel E shoreline would be applied to

Parcel B to minimize any impact on the bay during construction. Further refinement of the details of the shoreline revetment, including the plan for wetland mitigation, will occur during the RD. The RD will use updated information on shoreline conditions to select the actual engineering design parameters. Institutional controls will be implemented to maintain the integrity of the shoreline revetment at Parcel B.

<u>Alternative S-3: Excavation, Methane and Mercury Source Removal, Disposal, Maintained Landscaping, Institutional Controls and Shoreline Revetment</u>

Alternative S-3 consists of soil excavation and off-site disposal and institutional controls and maintained landscaping similar to Alternative S-2. Alternative S-3 also contains the same shoreline revetment component that is discussed with Alternative S-2. Areas where organic compounds (including the methane source), mercury, and lead are COCs will be excavated to remediate these COCs to remediation goals. This alternative will provide a more permanent remedy to remove contaminants where excavation is feasible. The institutional controls under this alternative would be used to prevent exposure to potential unacceptable risk posed by other COCs in soil (that is, the ubiquitous metals at concentrations above remediation goals). The institutional controls would be the same as Alternative S-2, would be implemented parcel-wide, and would be more fully described in an LUC RD document. Areas of bare or minimally vegetated soil that have been disturbed by excavation or construction and have not been restored with a cover will be covered by maintained landscaping as described in Alternative S-2.

The Navy plans to remove the source of methane as part of a time-critical removal action that is scheduled to be implemented before the ROD amendment is completed. The Navy will use visual observations of waste that may be the source of methane during the removal to guide the cleanup and will conduct a soil gas survey following the removal to identify whether methane is still present and may pose an unacceptable risk. The Navy will continue to discuss the remediation strategy for methane with the regulatory agencies during preparation of the proposed plan and ROD amendment.

Methane venting will be considered as a contingency in the event that excavation of the methane source area does not adequately control the methane emissions or if excavation is infeasible based on site conditions (for example, if methane is produced from organic material in the native sediments instead of from identifiable construction debris).

<u>Alternative S-4: Covers, Methane and Mercury Source Removal, Institutional Controls, and Shoreline Revetment</u>

Alternative S-4 consists of covers to ensure the exposure pathway to soil contaminants remains blocked and institutional controls similar to Alternatives S-2 and S-3. Alternative S-4 also contains the same methane and mercury source removal components that are described in Alternative S-3 and the shoreline revetment component included in Alternatives S-2 and S-3. This alternative provides physical barriers to cut off the exposure pathways to soil at Parcel B. Based on the ubiquitous nature of metal COCs that exceed remediation goals, the cover alternative would be applied redevelopment block-wide (that is, covers would be installed and/or maintained across an entire redevelopment block) wherever at least one risk grid within the block is identified by the HHRA (see Appendix A) as containing COCs at concentrations greater than the remediation goals. Existing covers, such as buildings and asphalt parking lots, are considered adequate for this alternative. New covers are considered for construction only in areas where there are no existing covers. The need for upgrades or repairs to the existing covers would be assessed in the RD and implemented for this alternative as necessary. The institutional controls are discussed in Section 4.3, would be implemented parcel-wide, and would be more fully described in an LUC RD document.

Alternative S-5: Excavation, Methane and Mercury Source Removal, Disposal, Covers, SVE, Institutional Controls, and Shoreline Revetment

Alternative S-5 consists of a combination of soil excavation (including methane and mercury source removal) and off-site disposal, covers, SVE for VOCs, institutional controls, and shoreline revetment. This alternative was developed as a combined alternative to (1) remove and dispose of organic COCs, mercury, and lead, as described in Alternative S-3, (2) implement and maintain block-wide covers, as described in Alternative S-4, (3) remove and treat VOCs in soil using SVE, and (4) implement the institutional controls and construct the shoreline revetment, as described in Alternative S-2.

5.1.2 Alternatives Developed for Groundwater

The following alternatives were developed for groundwater.

Alternative GW-1: No Action

No remedial action will be taken for this alternative. Groundwater conditions will be left as is, without implementing any response actions. The no-action response is retained throughout the evaluation process as required by the NCP to provide a baseline for comparison with other alternatives.

Alternative GW-2: Long-Term Groundwater Monitoring and Institutional Controls

Alternative GW-2 consists of groundwater monitoring and institutional controls. This alternative was developed as a method for monitoring groundwater contaminants present at low concentrations. Additionally, groundwater monitoring will be used to confirm site conditions and ensure that, over time, the potential exposure pathways remain incomplete. Two groundwater monitoring wells have been installed near well IR26MW47A to monitor concentrations of mercury in groundwater. A third well will be installed within the area of Excavation EE-05 after the final remedy is selected and the mercury source removal is completed. Alternative GW-2 will also provide for continued monitoring of the effectiveness of the ZVI injection treatability study. Institutional controls are also included in this alternative. The institutional controls are discussed in Section 4.3, would be implemented parcel-wide, and would be more fully described in an LUC RD document.

Alternatives GW-3A and GW-3B: *In Situ* Treatment, Groundwater Monitoring, and Institutional Controls

Alternatives GW-3A and GW-3B consist of *in situ* treatment of the contaminant plumes in addition to groundwater monitoring and institutional controls similar to Alternative GW-2. Alternatives GW-3A and GW-3B involve using different *in situ* treatment reagents (a biological substrate for 3A and ZVI for 3B plus an additional reagent for dissolved metals, as necessary), which are further described in Section 5.3.3. These alternatives were selected as a method of actively reducing groundwater contaminant volume and toxicity rather than using monitoring alone, as proposed in Alternative GW-2. Alternatives GW-3A and GW-3B are intended to reduce the required time to meet the groundwater RAOs and, as a result, the length of groundwater monitoring and possibly the time required for the institutional controls. The institutional controls in Alternatives GW-3A and GW-3B would be the same as in Alternative GW-2, would be implemented parcel-wide, and would be more fully described in an LUC RD.

5.2 DESCRIPTION OF SOIL REMEDIAL ALTERNATIVES

Soil at Parcel B presents a potential unacceptable risk to human health under the anticipated future land-use scenario evaluated in the HHRA for this TMSRA (see Appendix A and Section 3.0). Five remedial alternatives were developed for soil: (1) a no-action alternative, (2) an institutional control and shoreline revetment alternative, (3) a removal action alternative with institutional controls and shoreline revetment, (4) a containment alternative (including a shoreline revetment) with institutional controls and methane and mercury source removal, and (5) an alternative that combines the removal action and containment with institutional controls. All of these alternatives are designed to address potential unacceptable risk associated with the planned reuse for each of the redevelopment blocks in the HHRA. These alternatives are described in the following sections, including notes on the major design assumptions that were used to estimate costs and action-specific ARARs unique to each alternative. Appendix D contains a more complete description of design assumptions and detailed estimates of alternative costs. Table 5-1 presents the major components of each alternative to be implemented in each redevelopment block, including which grids contain COCs at concentrations above the remediation goals.

5.2.1 Alternative S-1: No Action

Under Alternative S-1, no remedial action will be taken. Soil would be left in place as is, without implementing any institutional controls, containment, removal, treatment, or other mitigating actions. The no-action response is retained throughout the evaluation process as required by the NCP to provide a baseline for comparison with other alternatives.

5.2.2 Alternative S-2: Institutional Controls, Maintained Landscaping, and Shoreline Revetment

Alternative S-2 consists of institutional control process options, maintained landscaping, and construction of a shoreline revetment. Institutional controls are described in detail in Section 4.3. Maintained landscaping will be required for areas that are currently bare or for minimally vegetated soils that have been disturbed by excavation or construction and have not been restored with a cover (for example, clean imported soil, asphalt, or concrete). The maintained landscaping will prevent potential exposure to asbestos (that may be present in surface soil and transported by wind erosion) that would not be addressed by institutional controls alone.

Alternative S-2 also includes construction of a shoreline revetment. The shoreline revetment would be constructed to protect the entire shoreline for Redevelopment Blocks BOS-1 and BOS-3, where the revetment was determined to be necessary based on the results of the SLERA. The 1,300-ft^2 wetland at Redevelopment Block BOS-1 would be filled and the Navy would mitigate the loss of the wetland using either compensatory mitigation, mitigation banking, or an in-lieu fee arrangement. Shoreline areas in Redevelopment Block BOS-1 and BOS-3 will be protected by revetments to reduce the possibility that contaminated soil will enter the bay. The revetments would cover the shoreline and consist of layers of riprap overlying geofabric filters designed to prevent erosion and migration of fine material. The revetments would extend from below the low tide line to above the high tide line with an allowance for wave "run-up." Approximately 2,500 feet of shoreline would need revetment. Figure 5-1 presents a conceptual design for the revetment.

Standard construction practices would be modified along the shoreline to minimize potential effects on the bay. These practices could include construction at low tide and using long-reach equipment. Knowledge the Navy gained during activities along the Parcel E shoreline would be applied to Parcel B to minimize any impact on the bay during construction. Further refinement of the details of the shoreline revetment, including the plan for wetland mitigation, will occur during the RD. The RD will use updated information on shoreline conditions to select the actual engineering design parameters.

A detailed discussion of several key design factors that affect the cost of the revetment is included in Appendix D.

5.2.3 Alternative S-3: Excavation, Methane and Mercury Source Removal, Disposal, Maintained Landscaping, Institutional Controls, and Shoreline Revetment

Alternative S-3 consists of excavation of contaminated soil; excavation of soil and debris in the methane and mercury source areas; off-site disposal of known and potentially contaminated soil and debris; maintained landscaping; institutional controls; and construction of a shoreline revetment.

Soil would be excavated in specific areas within selected areas at Parcel B, as described below:

- Soil contaminated with organic compounds and lead at concentrations that exceed remediation goals based on the planned reuse will be excavated. Excavation would occur to a maximum depth of 10 feet bgs at risk grid B3415 (for lead in Redevelopment Block 9; see Figure 5-2), B3426 (for lead in Redevelopment Block 8; see Figure 5-3) and B4716 (for organic compounds in Redevelopment Block 15; see Figure 5-4). The combined volume of soil for all three excavations is estimated to be less than 250 cubic yards.

- Soil and debris from the methane source area at Redevelopment Block 3 would be excavated (see Figure 5-5). The extent of the elevated concentrations of methane will be delineated by a soil gas survey to the remediation goal for methane (1.25 percent by volume in air), or lower as appropriate, to identify the methane source material. The cost estimate in this TMSRA assumes that the soil will be excavated to a depth of 20 feet bgs over an area of 50 feet by 150 feet (for an estimated volume of 5,600 cubic yards). Post-excavation monitoring of soil gas concentrations will be conducted to confirm methane levels meet the cleanup goal. If methane source removal is not feasible based on site conditions (for example, if methane is produced from organic material in the native sediments instead of from identifiable construction debris), methane venting may be added to mitigate potential risk from methane.

- Soil from the mercury source area at former Excavation EE-05 would be excavated (see Figure 5-6). The vertical extent of the mercury concentrations that exceed the remediation goal will be delineated to identify the mercury source material. Horizontal delineation can be estimated from the previous remedial action. The cost estimate in this TMSRA assumes that contaminated soil will be excavated from within the area of former Excavation EE-05 from 10 feet bgs to a depth of 15 feet bgs (the estimated depth of bedrock in the area) over an area of 60 feet by 250 feet (for an estimated volume of about 2,800 cubic yards).

- The need for excavation and removal of soil or sediment for construction of the shoreline revetment will be evaluated during the RD; the cost estimate for the shoreline revetment includes disposal of 6,000 cubic yards of sediment to establish appropriate grades and to allow placement of erosion control materials at appropriate elevations relative to sea level.

- The open excavations will be backfilled with clean soil and the excavated soil that contains COCs will be removed from the site and transported to an appropriate disposal facility.

- Areas of bare or minimally vegetated soil that have been disturbed by excavation or construction and have not been restored with a cover will be covered by maintained landscaping as described in Alternative S-2.

- All other areas that present potential unacceptable incremental risk from potential exposure to COCs in soil (see Figure 4-1) will be left in place and addressed through the use of institutional controls. The following bullets provide specific examples.

- Excavation is not proposed for any areas at Redevelopment Blocks 2, 3, and BOS-1 based on the presence of debris fill in those areas and the known difficulties of attempting removals in debris fill areas.
- Excavation is not proposed beneath existing buildings; building slabs and foundations act as adequate covers (grid B1626 and grids at Redevelopment Block 8).
- Excavation is not proposed to remove contaminants present at 10 feet bgs (except as discussed above for the mercury source area at Excavation EE-05); the overlying soil acts as an adequate cover (grids B4017, B4520, AX04, and AY03).

Under this alternative, institutional controls would prevent exposure to potential unacceptable risk posed by the soil left in place. Institutional controls are described in detail in Section 4.3.

Alternative S-3 also contains the same shoreline revetment component. (See the discussion in Alternative S-2.)

5.2.4 Alternative S-4: Covers, Methane and Mercury Source Removal, Institutional Controls, and Shoreline Revetment

Alternative S-4 consists of covers, excavation of soil and debris in the methane and mercury source areas and off-site disposal, institutional controls, and construction of a shoreline revetment. Under this alternative, the soil at Parcel B that presents a potential unacceptable risk will be remediated by installing covers that cut off the potential exposure pathway. Institutional controls would prevent exposure to potential unacceptable risk posed by the soil left in place.

Redevelopment blocks with soil that contains metals (including lead) and organic compounds that pose a potential unacceptable risk will be covered to allow for currently planned land uses. Covers will be applied to an entire redevelopment block if any grid within the block requires a cover based on ease and efficiency of implementation, consistency in long-term enforcement, and effectiveness of long-term maintenance.

Covers will be required at all redevelopment blocks to prevent human exposure to ubiquitous metals in soil that may pose an unacceptable risk.

Covers will be achieved in two ways:

- **Use of Existing Covers:** Existing asphalt and concrete surfaces and buildings will be considered existing covers. These may include existing building footprints, roads, and parking lots. These existing covers may require rehabilitation, such as sealing or repairing cracks.

- **New Covers:** Where covers are needed, areas will be covered with a durable material that will not break, erode, or deteriorate such that the underlying soil becomes exposed. Standard construction practices for roads, sidewalks, and buildings would likely be adequate to meet this performance standard. Other examples of covers could include a minimum 4 inches of asphalt or a minimum 2 feet of clean imported soil. All covers must achieve a full cover over the entire redevelopment block. The exact nature and specifications for covers can vary from block to block, but all covers must meet the performance standard of preventing exposure to soil and durability. Backfill for soil covers will be tested and confirmed to be below remediation goals and to contain less than 0.25 percent asbestos. The soil cover may overlay existing grades. Appropriate covers for the open space reuse blocks will depend on the details of redevelopment.

It is estimated from aerial photographs of Parcel B that approximately 9 acres will be covered with soil, 7 acres will be covered with new asphalt, 3 acres will be covered by the shoreline revetment, and 40 acres of existing asphalt and concrete surfaces (including buildings) will be used and repaired, as necessary (see Figure 5-8). The estimates for each redevelopment block are listed in the cost tables in Appendix D. The actual extent of cover types will be identified in the RD.

Institutional controls for all blocks will be based on the intended reuse for each redevelopment block and designed to meet the RAOs and ARARs. Institutional controls are described in detail in Section 4.3.

Alternative S-4 also contains the same shoreline revetment (see the discussion in Alternative S-2) and methane and mercury source removal (see discussions in Alternative S-3) components.

5.2.5 Alternative S-5: Excavation, Methane and Mercury Source Removal, Disposal, Covers, SVE, Institutional Controls, and Shoreline Revetment

Alternative S-5 consists of excavation of contaminated soil, excavation of soil and debris in the methane and mercury source areas, off-site disposal of known and potentially contaminated soil and debris, covers, SVE for VOCs, institutional controls, and construction of a shoreline revetment. Alternative S-5 combines the excavation and soil cover actions and adds SVE for VOCs to comply with all of the RAOs and ARARs and to be more protective.

Soil for Alternative S-5 would be excavated in those specific areas described in Alternative S-3. Covers would be provided for redevelopment blocks as described in Alternative S-4.

Alternative S-5 would include the expansion and continued operation of the pilot-scale SVE system that was operated at Redevelopment Block 8 (Building 123). SVE would be implemented as a source reduction measure and the other actions associated with Alternative S-5 would provide overall protectiveness to meet the RAOs.

As with Alternative S-2, this alternative contains institutional controls. Institutional controls will be based on the intended reuse for each redevelopment block and designed to meet the RAOs and ARARs. Institutional controls are described in detail in Section 4.3.

Alternative S-5 also contains the same shoreline revetment (see the discussion in Alternative S-2) and methane and mercury source removal (see discussions in Alternative S-3) components.

5.3 DESCRIPTION OF GROUNDWATER REMEDIAL ALTERNATIVES

Groundwater in the A-aquifer presents a potential unacceptable risk by the indoor air inhalation pathway of VOCs as a result of vapor migration from the groundwater; therefore, VOCs were identified as COCs that require remedial action. In addition, the SLERA has identified mercury as a COC that poses a potential risk to San Francisco Bay. Chromium VI, copper, lead, and mercury were also identified as COCs based on the potential migration of groundwater to the surface water of the bay. Based on the HHRA, no COCs in the B-aquifer at Parcel B exceed remediation goals.

Three remedial alternatives were developed for groundwater: (1) no action, (2) long-term groundwater monitoring and institutional controls, and (3) *in situ* treatment with reduced monitoring and institutional controls. These alternatives are described in the following sections. Table 5-2 presents the major components of each alternative to be implemented in each redevelopment block, including the grids and monitoring wells that contain COCs at concentrations above the remediation goals.

5.3.1 Alternative GW-1: No Action

Under Alternative GW-1, no remedial action will be taken. Groundwater would be left as is without implementing any institutional controls, containment, removal, treatment, monitoring, or other mitigating actions. The no-action response is retained throughout the evaluation process as required by the NCP to provide a baseline for comparison with other alternatives.

5.3.2 Alternative GW-2: Long-Term Groundwater Monitoring and Institutional Controls

Alternative GW-2 consists of groundwater monitoring and institutional controls. The groundwater monitoring addresses all of the COCs identified in Section 3.0, whether they were derived from the HHRA in Appendix A, from the SLERA discussed in Appendix B, or the surface water quality screening evaluation discussed in Appendix I.

Groundwater in the A-aquifer would be monitored where metals and VOCs are detected at concentrations above remediation goals. The general objectives for groundwater monitoring for Alternative GW-2 are summarized below; Table 5-3 presents the individual wells and analytes proposed for monitoring and a brief rationale. Figure 5-7 shows the locations of the proposed monitoring wells, the ZVI and SVE treatability studies at Parcel B, and the anaerobic/aerobic bioremediation treatability study at Parcel C. Two groundwater monitoring wells have been installed near well IR26MW47A to monitor concentrations of mercury in groundwater. A third well will be installed within the area of Excavation EE-05 after the final remedy is selected and the mercury source removal is completed. Details of groundwater monitoring (such as wells to be monitored, analytes to be sampled, laboratory analytical methods, sample collection procedures, and quality control requirements) will be included in the RD that will be prepared after the ROD amendment is completed. Additionally, the Navy is implementing an adaptable strategy for groundwater monitoring based on the Triad approach to allow flexibility to optimize monitoring. This strategy may be included in the future design of the groundwater monitoring program and, if implemented, could change the proposed monitoring wells and analytes presented in the TMSRA. Results of groundwater monitoring will be used during five-year reviews to assess the monitoring program, adjust the data collection and analysis requirements, and evaluate the need for other response actions. Groundwater monitoring would continue until remediation goals are met.

The overall objectives for groundwater monitoring include:

- Monitor the potential migration of COCs into previously uncontaminated areas and potential migration toward San Francisco Bay
- Monitor the changes in concentrations within a plume, including the effects of remedial actions and previous treatability studies
- Monitor concentrations in and near individual wells where the HHRA indicated potential risk

Institutional controls are part of Alternative GW-2 and are described in detail in Section 4.3. Institutional controls would be in place to prohibit use of buildings or other enclosures where there is potential unacceptable risk from the vapor intrusion pathway and require engineering controls on all new buildings occupied in redevelopment blocks where groundwater plumes may present potential unacceptable risk from the vapor intrusion pathway.

Institutional controls will be required for an entire redevelopment block if any portion of that block is affected by the potential lateral extent of vapor intrusion. Figure A-8 presents the potential lateral extent of vapor intrusion and shows that all redevelopment blocks, except Blocks 1, 2, and 4 would require institutional controls for vapor intrusion. The Navy proposes to implement institutional controls for vapor intrusion across all of Parcel B based on ease and efficiency of implementation, consistency in long-term enforcement, and effectiveness in long-term maintenance. Institutional controls for vapor intrusion will remain in place as long as the concentrations in the underlying groundwater exceed remediation goals.

5.3.3 Alternatives GW-3A and GW-3B: *In Situ* Treatment with Reduced Groundwater Monitoring, and Institutional Controls

Alternatives GW-3A and GW-3B consists of three retained process options: (1) *in situ* treatment of groundwater, (2) reduced groundwater monitoring compared with the monitoring only alternative (Alternative GW-2), and (3) institutional controls. The analysis of Alternatives GW-3A and 3B was based on *in situ* injection treatments. The only difference between Alternatives GW-3A and GW-3B are the types of materials used to treat the groundwater. The groundwater treatment materials evaluated are a substrate for biodegradation (Alternative GW-3A) or a slurry of ZVI for chemical reduction (Alternative GW-3B).

- *In situ* treatment uses either the biodegradation substrate or ZVI to actively mitigate contaminants where concentrations are highest in the IR-10A groundwater plume. This treatment is based on the groundwater plume defined by the most recent groundwater data, presented on Figure 5-7. Further refinement of the details of *in situ* treatment options will occur during the RD. Plume conditions may continue to change over time as a result of the continued effects of treatability studies. The RD will use updated information on plume extent and concentration to select the actual injection parameters. The assumed process involves a single injection of the treatment compound into groundwater to reduce the contaminant concentrations to or near remediation goals. The treatment process also assumes that a successful injection can be implemented, as demonstrated during the pilot study at Parcel B where 130,500 pounds of ZVI was injected in 2003.

  Relatively low concentrations of the COCs in the groundwater at Parcel B are observed compared with other remedial sites where injection treatments have been successful; therefore, using either biodegradation substrate or ZVI as the injection material has a high probability of success with one inoculation. However, there are differences in the way that these materials affect the COCs.

  The biodegradation substrate (Alternative GW-3A) is a glycerol polylactate, which creates reducing conditions in the aquifer by forming lactic acid and hydrogen. The microbes use the lactic acid and hydrogen to degrade or mineralize the VOCs to their basic components by a process called reductive dechlorination. This biodegradation substrate treatment is a timed-release compound that will continue to react for up to several years, depending on the dose of the treatment. This timed-release reaction is beneficial in low-permeability aquifers such as the A-aquifer at Parcel B because the slow release allows more time for dispersion of the substrate and more time for the substrate to come in contact with the COCs and cause them to be immobilized or mineralized.

  The ZVI treatment (Alternative GW-3B) injects a slurry of permeable carrier fluid with fine particles of ZVI. The ZVI reacts in groundwater to produce intermediate products such as hydrogen, which react with VOCs and cause reductive dechlorination and mineralization. This reaction occurs quickly and readily and is beneficial even for very high concentrations of dissolved COCs. The ZVI treatment may also be used effectively for low concentrations of VOCs. The ZVI often creates a favorable environment for microbial dechlorination after the initial chemical reaction, depending on the dose of the ZVI. This alternative assumes a single, additional inoculation will be necessary.

- *In situ* treatment for metals (chromium VI, copper, lead, and mercury), if necessary, will use an organo-sulfur compound that causes anaerobic bioactivity to immobilize metal contaminants. Using the injected material, the microbes produce a metal-organo-sulfur complex that strongly sorbs to the aquifer matrix. Removal of the mercury source as part of the soil remedy is expected to mitigate mercury in groundwater so that *in situ* treatment is not necessary. The need to treat chromium VI, copper, and lead will be based on the further analysis of groundwater data against trigger levels that will occur during the RD.

- Treatability studies using the technologies proposed in Alternatives GW-3A and GW-3B have been shown to be effective at Parcel B or nearby sites with similar conditions.

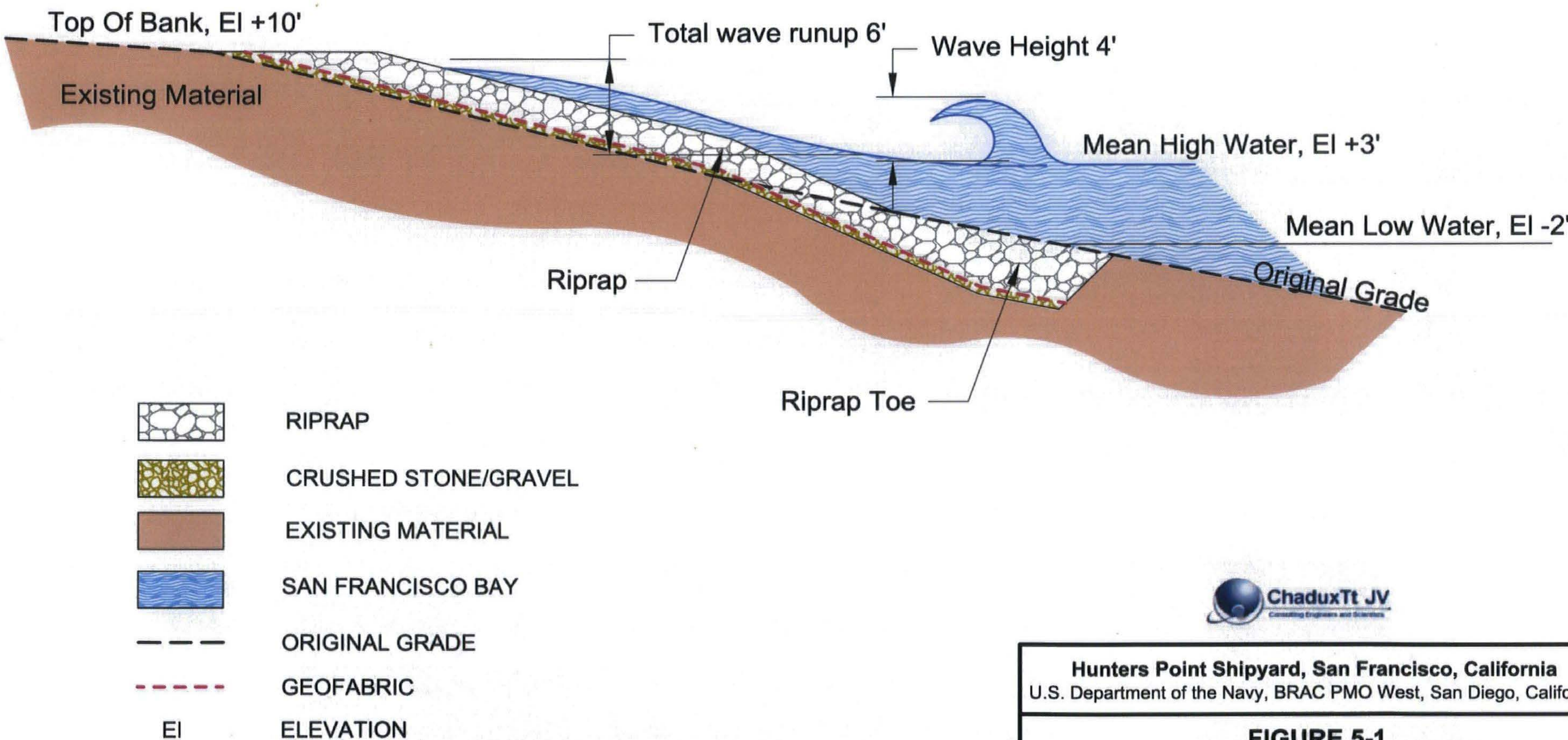
- Groundwater will be monitored quarterly for Alternatives GW-3A and GW-3B for the first year while the treatment is being implemented. The monitoring frequency will be reduced to semiannual events for years 2, 3, and 4, then monitoring will occur annually thereafter (starting in year 5). Near the end of the monitoring period for Alternatives GW-3A and GW-3B (assumed to occur in year 15) monitoring will be quarterly for a 1-year "proof period" to demonstrate attainment of remediation goals. Alternatives GW-3A and GW-3B assume that only 1 year of proof period will be required to demonstrate achievement of the RAOs associated with the IR-10A plume. Groundwater monitoring in the IR-10A plume area ceases after year 15, but continues at other locations outside the plume.

- The 15-year period for groundwater monitoring is assumed to develop the cost estimates for Alternatives GW-3A and GW-3B. However, the actual monitoring period could be shorter or longer depending on data collected during the RD and remedial action.

- The current locations of the VOC plumes at IR-25 in Parcel C do not extend into Parcel B (see Figure 4-2), and active groundwater treatment is not proposed at Parcel B for any of the plume area used in the risk assessment that was shown in Parcel B. The VOC plumes at IR-25 will be addressed in the Parcel C FS. However, monitoring of wells IR24MW04A, IR25MW61A1, and IR25MW61A2 at Parcel B is included as part of the groundwater monitoring component of the groundwater alternatives for this TMSRA. These wells are located where the IR-25 risk plume is mapped within Parcel B. If, during this monitoring, VOCs are detected along the boundary between Parcels B and C at concentrations that require action, the remedies proposed for the IR-25 plume under the Parcel C FS would be pursued.

The institutional controls for this alternative would be the same as were described in Alternative GW-2.

FIGURES



Existing riprap will be stockpiled and integrated into final riprap cover.
All elevations feet above National Geodetic Vertical Datum-1929 Datum.

NOT TO SCALE

ChaduxTt JV

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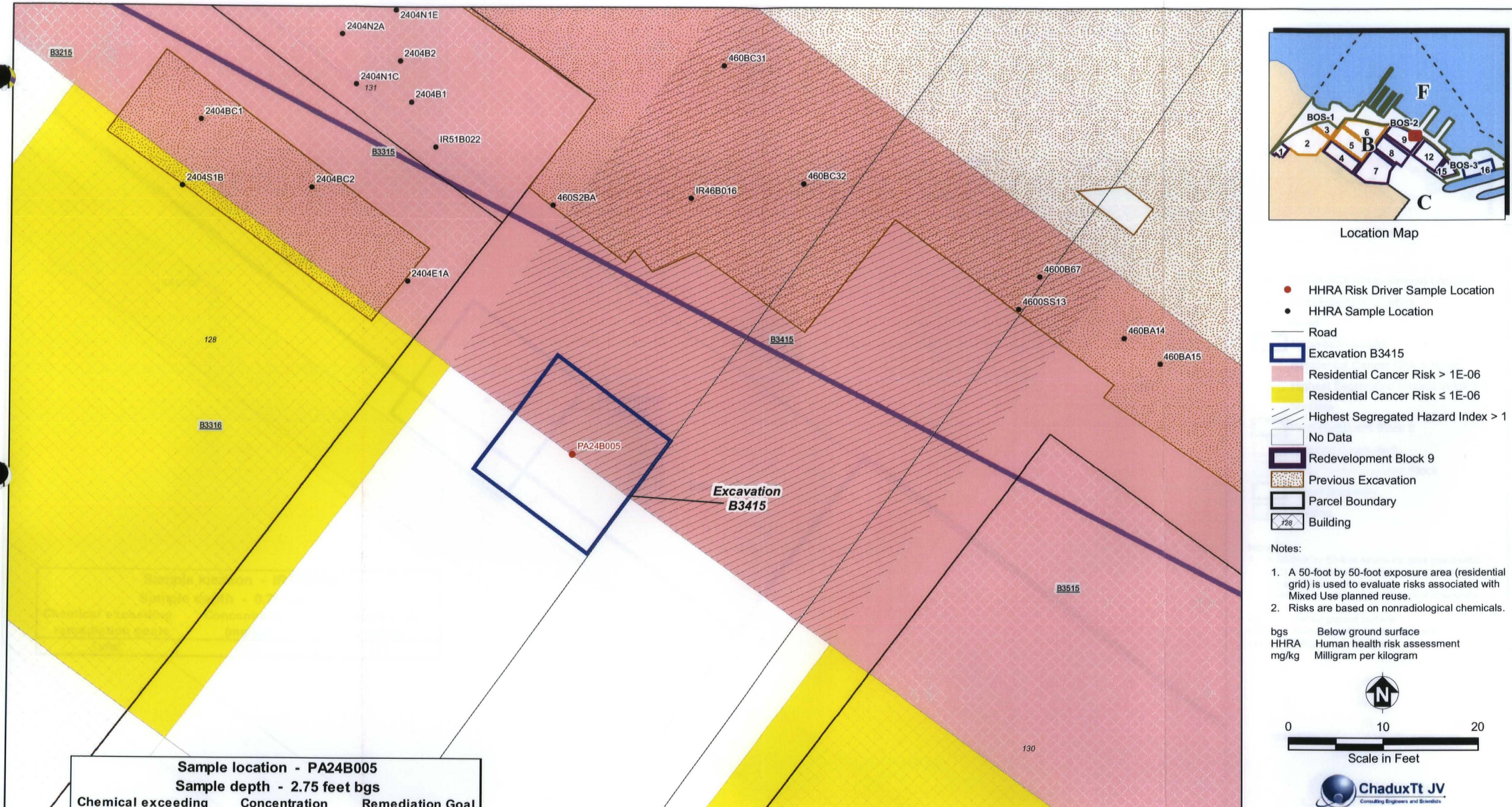
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 5-1
SCHEMATIC CROSS SECTION OF SHORELINE REVETMENT

TMSRA for Parcel B



Sample location - PA24B005
Sample depth - 2.75 feet bgs

Chemical exceeding remediation goals	Concentration (mg/kg)	Remediation Goal (mg/kg)
Lead	165	155

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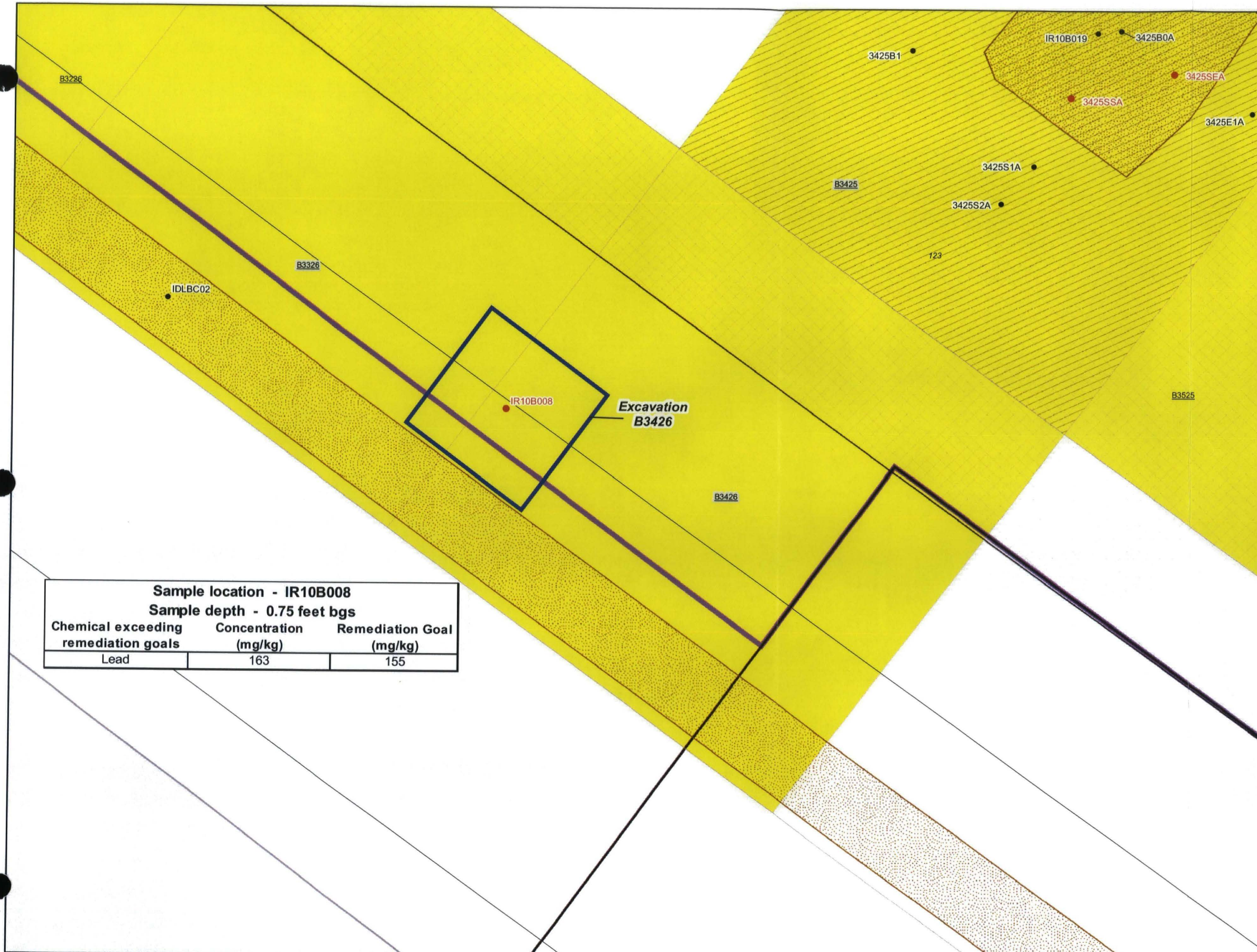
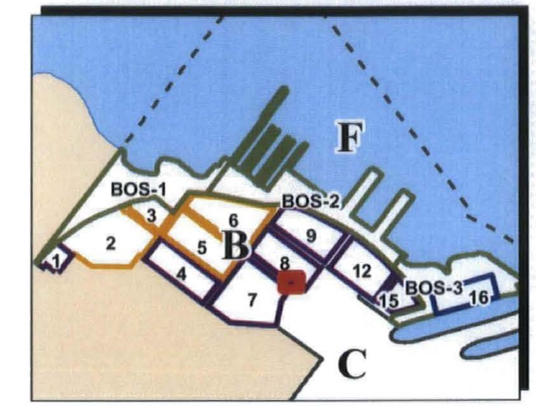
FIGURE 5-2
PROPOSED EXCAVATION
B3415 AREA

TMSRA for Parcel B



Sample location - IR10B008		
Sample depth - 0.75 feet bgs		
Chemical exceeding remediation goals	Concentration (mg/kg)	Remediation Goal (mg/kg)
Lead	163	155



Location Map

- HHRA Risk Driver Sample Location
- HHRA Sample Location
- Road
- Excavation B3426
- Residential Cancer Risk ≤ 1E-06
- Highest Segregated Hazard Index > 1
- No Data
- Redevelopment Block 8
- Previous Excavation
- Other Redevelopment Block
- Parcel Boundary
- Building

Notes:
1. A 50-foot by 50-foot exposure area (residential grid) is used to evaluate risks associated with Mixed Use planned reuse.
2. Risks are based on nonradiological chemicals.

bgs Below ground surface
HHRA Human health risk assessment
mg/kg Milligram per kilogram

N

0 10 20
Scale in Feet

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FIGURE 5-3
PROPOSED EXCAVATION
B3426 AREA

TMSRA for Parcel B

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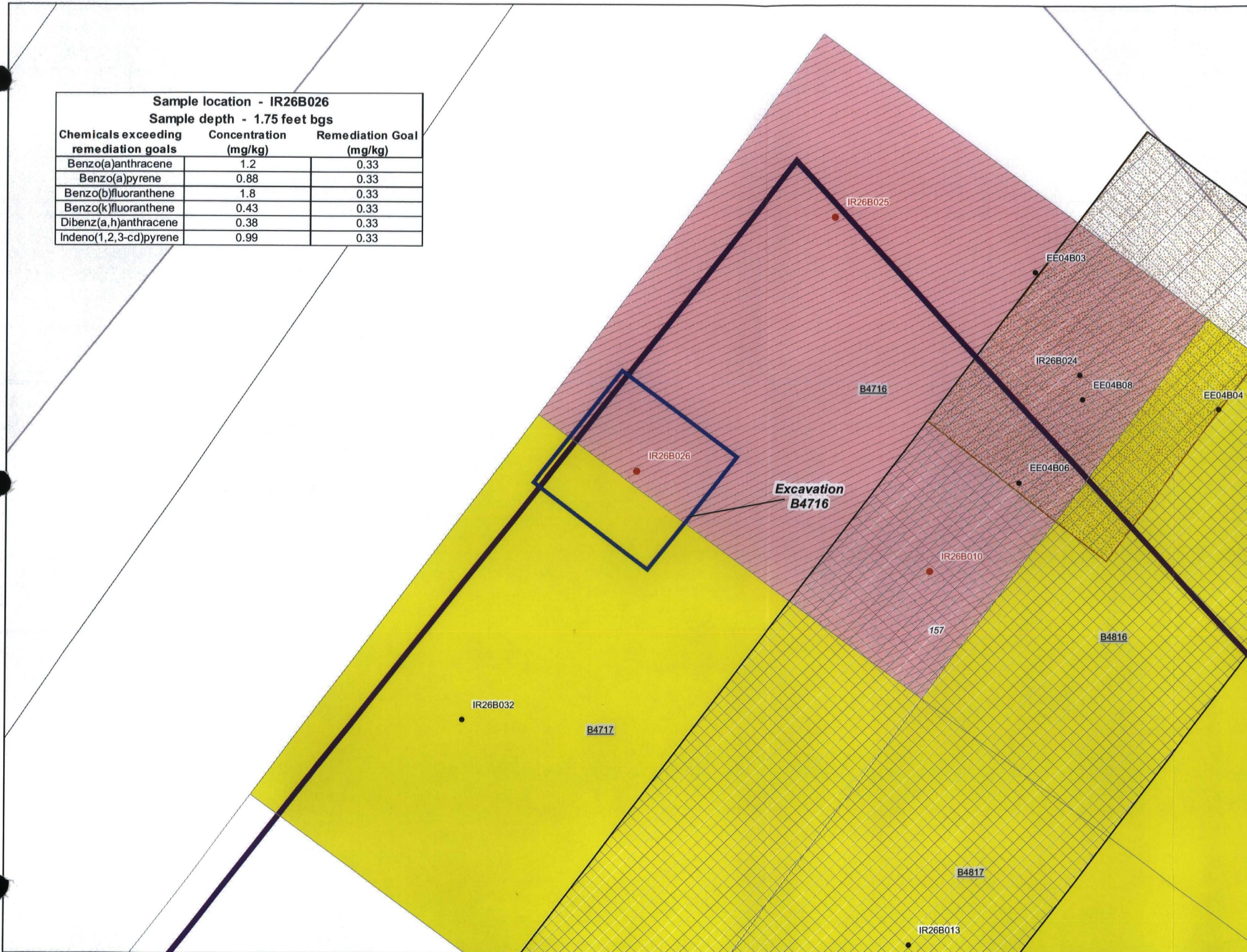
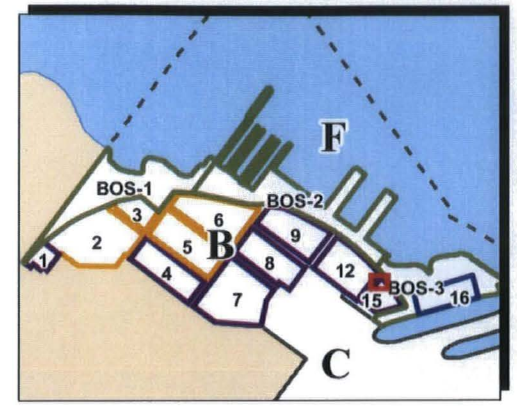
Sample location - IR26B026		
Sample depth - 1.75 feet bgs		
Chemicals exceeding remediation goals	Concentration (mg/kg)	Remediation Goal (mg/kg)
Benzo(a)anthracene	1.2	0.33
Benzo(a)pyrene	0.88	0.33
Benzo(b)fluoranthene	1.8	0.33
Benzo(k)fluoranthene	0.43	0.33
Dibenz(a,h)anthracene	0.38	0.33
Indeno(1,2,3-cd)pyrene	0.99	0.33





Location Map

- HHRA Risk Driver Sample Location
- HHRA Sample Location
- Road
- Excavation B4716
- Residential Cancer Risk > 1E-06
- Highest Segregated Hazard Index > 1
- Residential Cancer Risk ≤ 1E-06
- Redevelopment Block 15
- Previous Excavation
- Building
- Other Redevelopment Block

Notes:
1. A 50-foot by 50-foot exposure area (residential grid) is used to evaluate risks associated with Mixed Use planned reuse.
2. Risks are based on nonradiological chemicals.

bgs Below ground surface
HHRA Human health risk assessment
mg/kg Milligram per kilogram

N

0 10 20
Scale in Feet

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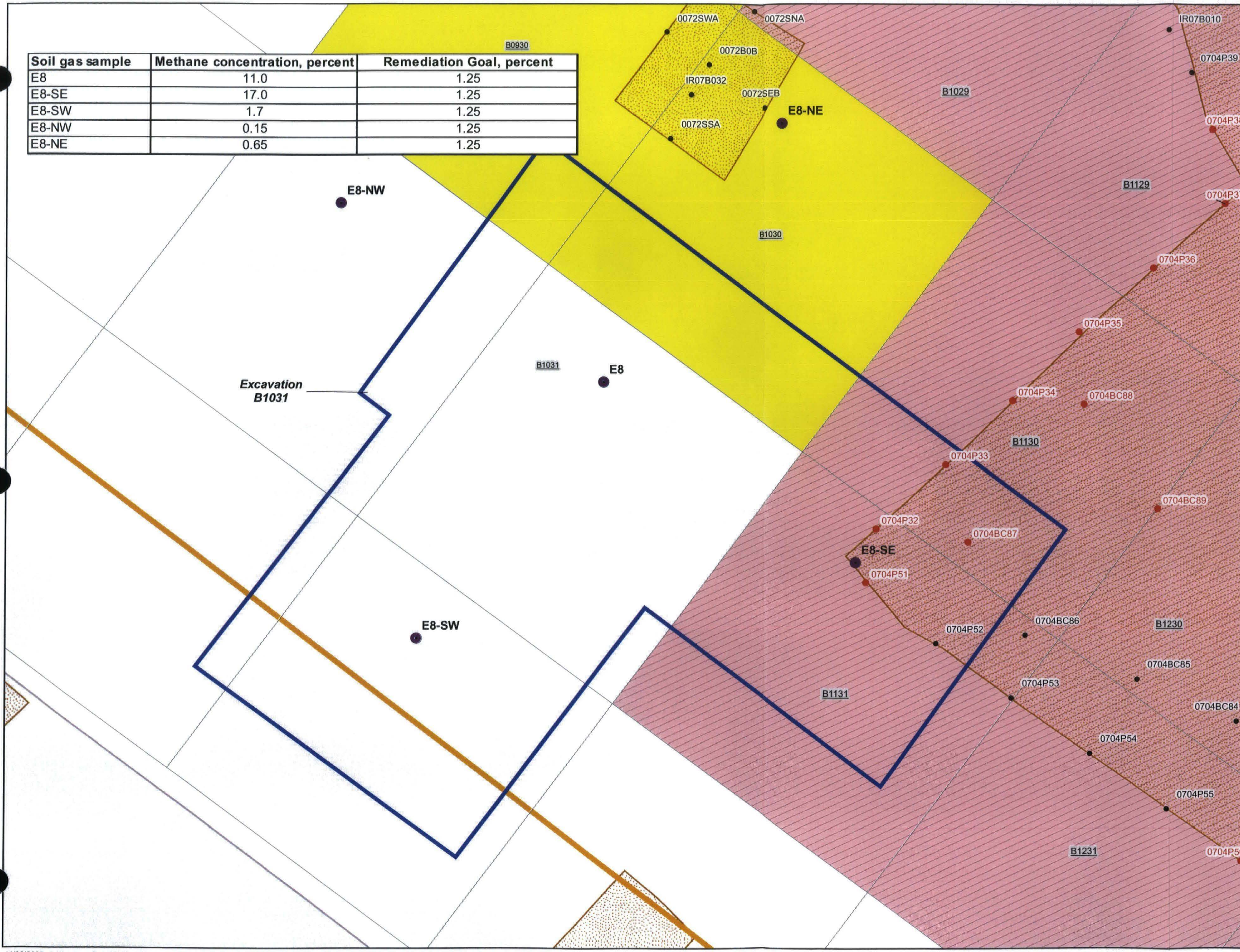
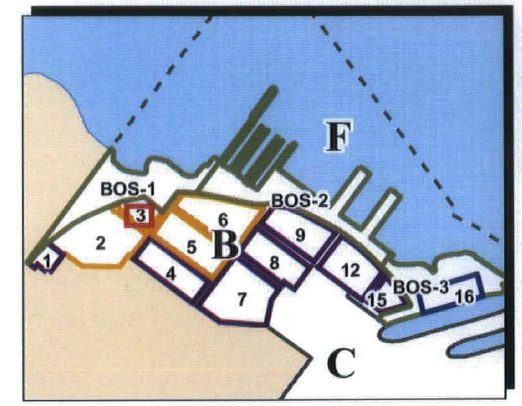
U.S. Department of the Navy, BRAC PMO West, San Diego, California

FIGURE 5-4
PROPOSED EXCAVATION
B4716 AREA

TMSRA for Parcel B

Soil gas sample	Methane concentration, percent	Remediation Goal, percent
E8	11.0	1.25
E8-SE	17.0	1.25
E8-SW	1.7	1.25
E8-NW	0.15	1.25
E8-NE	0.65	1.25





Location Map

Soil Gas Sample Location
HHRA Risk Driver Sample Location
HHRA Sample Location
Road
Excavation B1031
Residential Cancer Risk > 1E-06
Highest Segregated Hazard Index > 1
Residential Cancer Risk ≤ 1E-06
Redevelopment Block 3
Previous Excavation
Other Redevelopment Block

Notes:
1. A 50-foot by 50-foot exposure area (residential grid) is used to evaluate risks associated with Mixed Use planned reuse.
2. Risks are based on nonradiological chemicals.

HHRA Human health risk assessment

N

0 15 30

Scale in Feet

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FIGURE 5-5
PROPOSED EXCAVATION B1031 AREA FOR METHANE SOURCE REMOVAL

TMSRA for Parcel B

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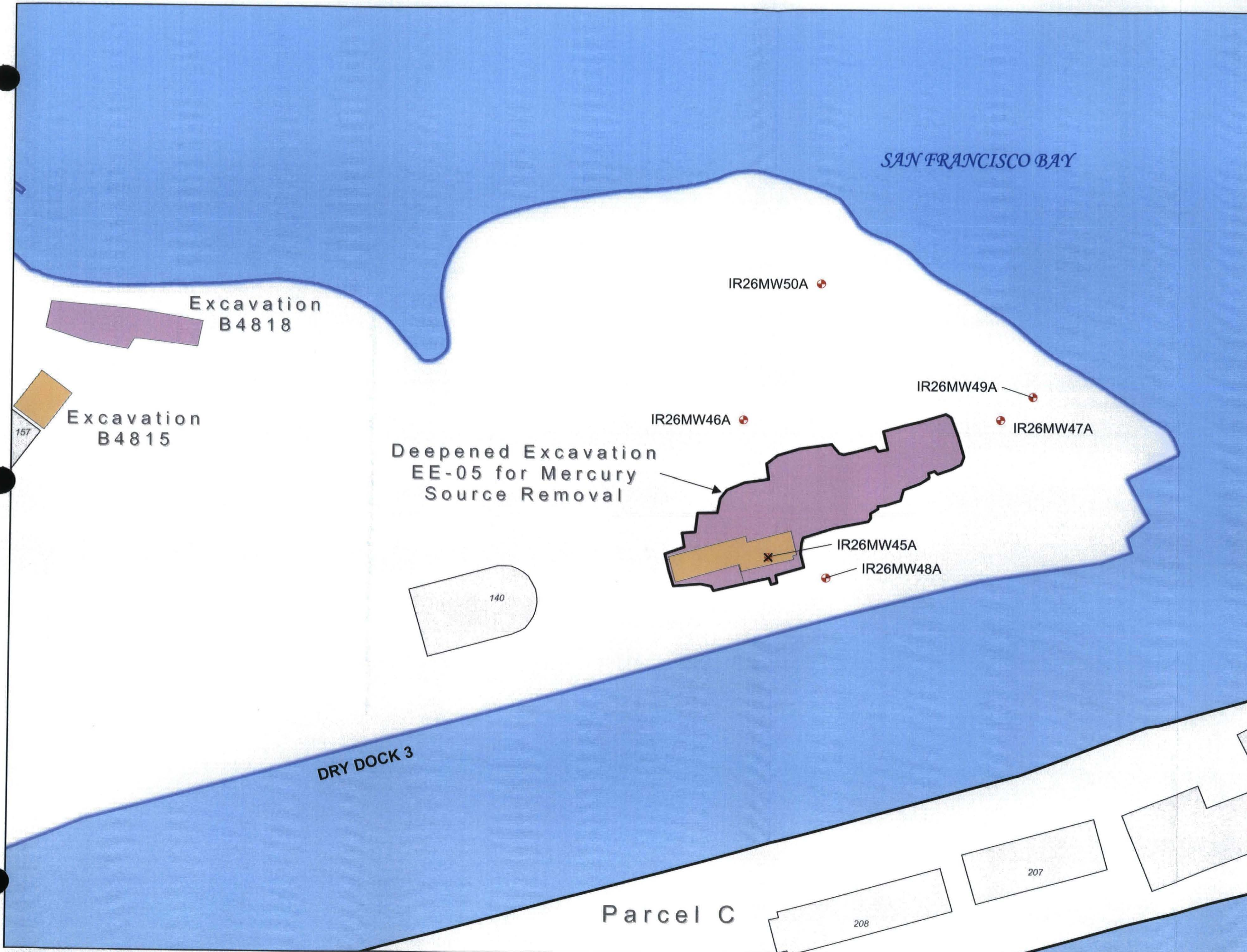

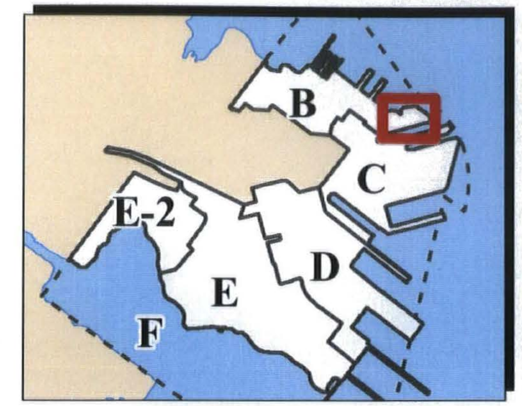

Location Map

RAMP Monitoring Well
Decommissioned RAMP Monitoring Well
Excavation Extent (pre-2001)
Excavation Extent (2001)
Parcel B Boundary
Other Parcel Boundary
128 Building
San Francisco Bay

Notes:

1. Excavation planned to extend from base of previous excavation (7 or 10 feet) to bedrock (about 15 feet below ground surface).
2. Depth to groundwater in this area is about 6.5 to 8.0 feet below ground surface.

RAMP Remedial action monitoring program

N

0 75 150
Scale in Feet

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FIGURE 5-6
PROPOSED EXCAVATION EE-05 AREA FOR MERCURY SOURCE REMOVAL

TMSRA for Parcel B

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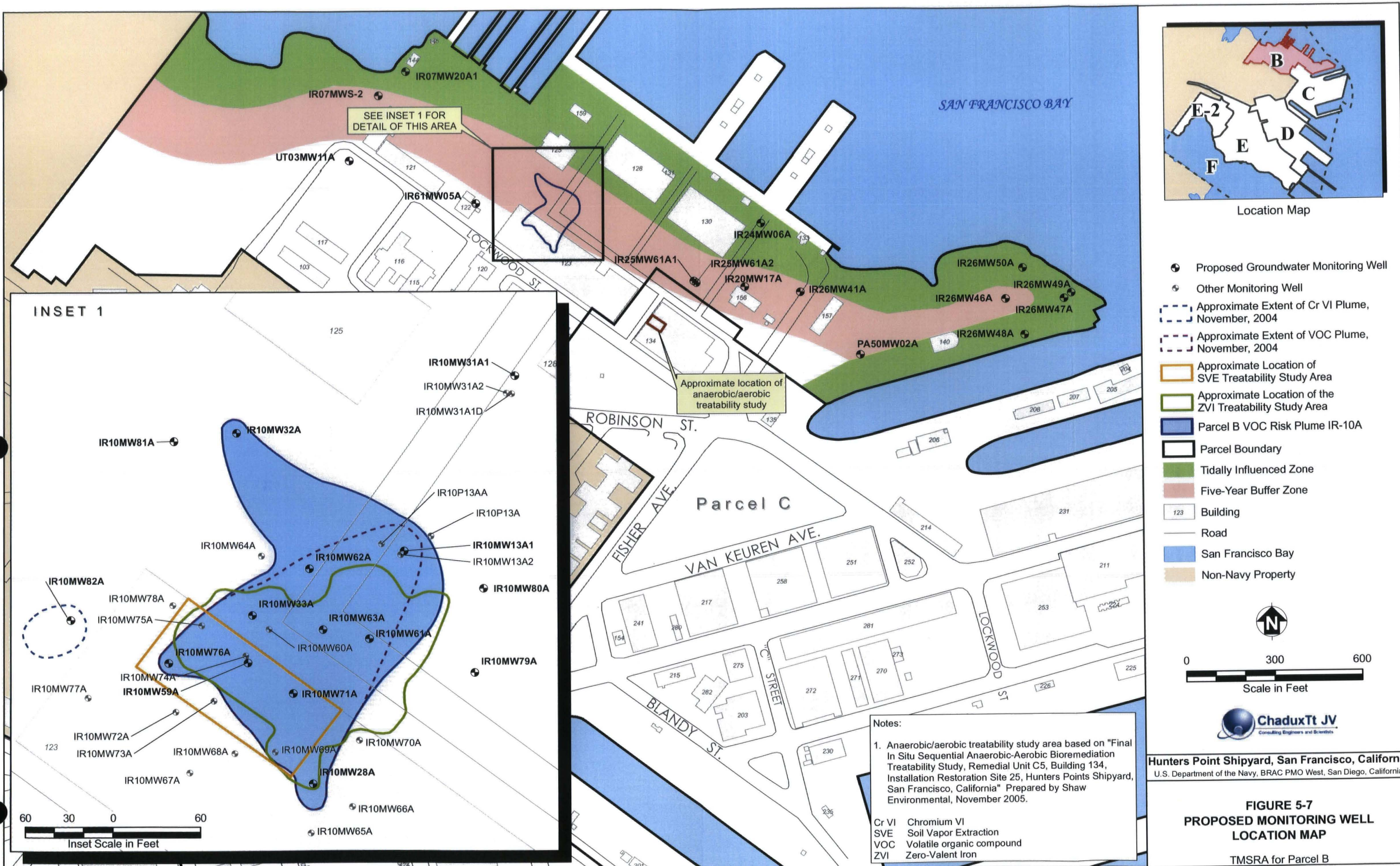

Notes:

1. Anaerobic/aerobic treatability study area based on "Final In Situ Sequential Anaerobic-Aerobic Bioremediation Treatability Study, Remedial Unit C5, Building 134, Installation Restoration Site 25, Hunters Points Shipyard, San Francisco, California" Prepared by Shaw Environmental, November 2005.

Cr VI Chromium VI
SVE Soil Vapor Extraction
VOC Volatile organic compound
ZVI Zero-Valent Iron

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FIGURE 5-7
PROPOSED MONITORING WELL LOCATION MAP

TMSRA for Parcel B

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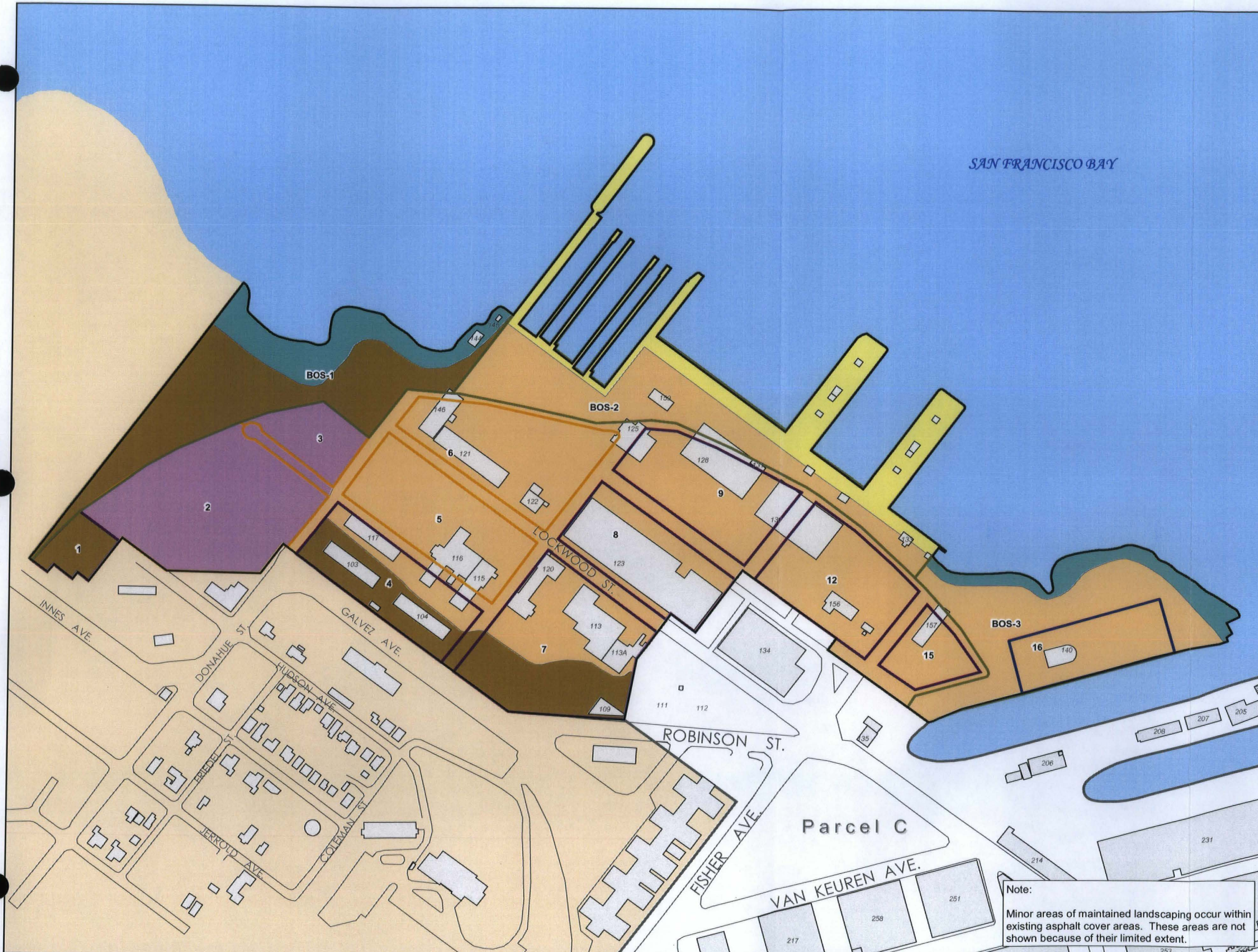

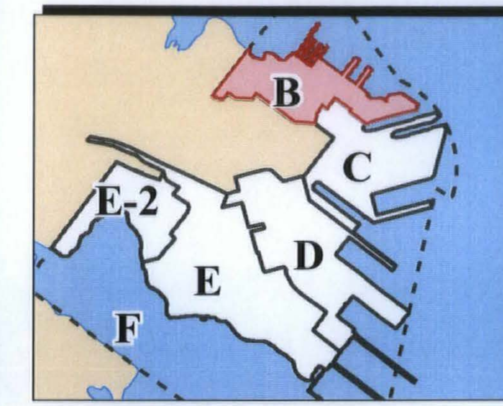

Location Map

Proposed Cover Type

- Existing Asphalt (Repaired)
- New Asphalt
- New Shoreline Revetment
- New Soil
- Pier Area

Land Use Designation

- Research and Development
- Mixed Use
- Open Space
- Educational/Cultural
- 128 Building
- Parcel B Boundary
- Other Parcel Boundary
- Road
- San Francisco Bay
- Non-Navy Property

0 300 600

Scale in Feet

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FIGURE 5-8
PROPOSED COVER TYPES

TMSRA for Parcel B

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TABLES

TABLE 5-1: MAJOR COMPONENTS OF SOIL ALTERNATIVES BY REDEVELOPMENT BLOCK

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

		Soil Alternative				
Redevelopment Block[a]	**Risk Grid with COC Exceeding Remediation Goal**	**S-1 No Action**	**S-2 ICs[b] Maintained Landscaping[c], and Shoreline Revetment**	**S-3c Excavation, Methane and Mercury Source Removal, Disposal, Maintained Landscaping[c], ICs[b], and Shoreline Revetment**	**S-4 Covers, Methane and Mercury Source Removal, Disposal, ICs[b], and Shoreline Revetment**	**S-5 Excavation, Methane and Mercury Source Removal, Disposal, Covers, SVE, ICs[b], and Shoreline Revetment**
1	None	No action	IC	IC	Cover block	Cover block
2	B0142, B0438, B0336, B0538	No action	IC	IC	Cover block	Cover block
3	B0632, B0928, B1028, B1029, B1128, B1129, B1130, B1131, B1228, B1229, B1230, B1231, B1328, B1330, B1331, Methane Source Removal Area	No action	IC	Excavate methane source and IC	Excavate methane source and cover block	Excavate methane source and cover block
4	None	No action	IC	IC	Cover block	Cover block
5	None	No action	IC	IC	Cover block	Cover block
6	B1426, B1626	No action	IC	IC	Cover block	Cover block
7	B2635, B2727, B2735, B3128, B3228, B3229	No action	IC	IC	Cover block	Cover block
8	B2722, B2723, B2724, B2823, B2824, B2923, B2924, B2726, B3126, B3425, B3426, B3622	No action	IC	Excavate lead sample at IR10B008; IC	Cover block	Excavate lead sample at IR10B008; SVE in VOC area under Building 123 (B2723, B2724, B2823, B2824, B2923, B2924); cover block

TABLE 5-1: MAJOR COMPONENTS OF SOIL ALTERNATIVES BY REDEVELOPMENT BLOCK (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

		Soil Alternative				
Redevelopment Block[a]	Risk Grid with COC Exceeding Remediation Goal	S-1 No Action	S-2 ICs[b] Maintained Landscaping[c], and Shoreline Revetment	S-3c Excavation, Methane and Mercury Source Removal, Disposal, Maintained Landscaping[c], ICs[b], and Shoreline Revetment	S-4 Covers, Methane and Mercury Source Removal, Disposal, ICs[b], and Shoreline Revetment	S-5 Excavation, Methane and Mercury Source Removal, Disposal, Covers, SVE, ICs[b], and Shoreline Revetment
9	B3117, B3118, B3217, B3218, B3415, B3421	No action	IC	Excavate lead sample at PA24B005; IC	Cover block	Excavate lead sample at PA24B005; cover block
12[d]	B3718, B3815, B3816, B4015, B4017, B4019, B4020, B4116, B4217, B4219, B4220, B4315, B4320, B4517, B4615, B4617	No action	IC	IC	Cover block	Cover block
15	B4716	No action	IC	Excavate PAH sample at IR26B026 and excavate mercury at EE-05; IC	Excavate mercury at EE-05; cover block	Excavate PAH sample at IR26B026 and mercury at EE-05; cover block
16	EE-05	No action	IC	Excavate mercury at EE-05 and IC	Excavate mercury at EE-05; cover block	Excavate mercury at EE-05; cover block
BOS-1	AG09, AH09, AI08	No action	Shoreline revetment and IC	Shoreline revetment and IC	Shoreline revetment, cover block	Shoreline revetment, cover block
BOS-2	None	No action	IC	IC	Cover block	Cover block
BOS-3	AU05, AW03	No action	Shoreline revetment and IC	Excavate mercury at EE-05; shoreline revetment and IC	Excavate mercury at EE-05; shoreline revetment, cover block	Excavate mercury at EE-05; shoreline revetment, cover block

TABLE 5-1: MAJOR COMPONENTS OF SOIL ALTERNATIVES BY REDEVELOPMENT BLOCK (CONTINUED)

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Notes:	Only the major components of each alternative for soil are listed in the table; supporting components are not listed. For example, ICs are part of all alternatives, except no action, but ICs are listed only where they are the primary component of the alternative.
	Excavation is not proposed for any areas at Redevelopment Blocks 2, 3, and BOS-1 based on the presence of debris fill in those areas and the known difficulties of attempting removals in debris fill areas.
	Excavation is not proposed beneath existing buildings; building slabs and foundations act as adequate covers (grid B1626 and grids at Redevelopment Block 8).
	Excavation is not proposed to remove contaminants present at 10 feet bgs; the overlying soil acts as an adequate cover (grids B4017, B4520, AX04, and AY03).
a	Redevelopment Blocks 1, 4, 5, and BOS-2 list no risk grids because there were no unacceptable risks from soil.
b	ICs for all alternatives will be applied to all redevelopment blocks, parcelwide.
c	Maintained landscaping will be required at all redevelopment blocks where currently bare or minimally vegetated soil has been disturbed by excavation or construction activities (primarily from the radiological removal actions) and not restored with a cover of clean imported soil, asphalt, or concrete.
d	Grid B4520 was excluded because the samples that contained soil with unacceptable risk were at 10 feet bgs.
EE	Exploratory excavation
IC	Institutional control
PAH	Polynuclear aromatic hydrocarbon
SVE	Soil vapor extraction
VOC	Volatile organic compound

TABLE 5-2: MAJOR COMPONENTS OF GROUNDWATER ALTERNATIVES BY REDEVELOPMENT BLOCK
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Redevelopment Block[a]	Plume or Risk Grid and Monitoring Well with COC Exceeding Remediation Goal	Groundwater Alternative			
		GW-1 No Action	GW-2 Long-Term Monitoring and ICs[b]	GW-3A *In Situ* Groundwater Treatment with Biological Amendment, Reduced Groundwater Monitoring, and ICs[b]	GW-3B *In Situ* Treatment with ZVI Injection, Reduced Groundwater Monitoring, and ICs[b]
5	B1528 (IR07MWS-1)	No action	Long-term monitoring and ICs	Long-term monitoring and ICs	Long-term monitoring and ICs
8	IR10A VOC plume IR25 VOC plume	No action	Long-term Monitoring and ICs	IR10A – Biological amendment injection IR25 – Long-term monitoring and remedy consistent with Parcel C remedy	IR10A-ZVI injection IR25-Long-term monitoring and remedy consistent with Parcel C remedy
9	IR10A VOC plume	No action	Long-term monitoring and ICs	Biological amendment injection	ZVI injection
12	IR25 VOC plume B4516 (IR20MW17A, IR24MW04A, IR25MW61A1, IR25MW61A2)	No action	Long-term monitoring and ICs	IR25 – Long-term monitoring and remedy consistent with Parcel C remedy B4516 – Long-term monitoring and ICs	IR25 – Long-term Monitoring and remedy consistent with Parcel C remedy B4516– Long-term monitoring and ICs
15	B5117 (PA50MW02A)	No action	Long-term monitoring and ICs	Long-term monitoring and ICs	Long-term monitoring and ICs
16	AY04 (former IR26MW45A)	No action	Long-term monitoring and ICs	Long-term monitoring and ICs	Long-term monitoring and ICs
BOS-1	AJ07, AJ08 (IR07MWS-2 IR07MW20A1)	No action	Long-term monitoring and ICs	Long-term monitoring and ICs	Long-term monitoring and ICs
BOS-3	AY02 (IR26MW47A)	No action	Long-term monitoring and ICs	Long-term monitoring and ICs	Long-term monitoring and ICs

Notes:	Only the major components of each groundwater alternative are listed in the table; supporting components are not listed. For example, ICs are part of all alternatives, except no action, but ICs are listed only where they are the primary component of the alternative.
a	Redevelopment Blocks 1, 2, 3, 4, 6, 7, and BOS-2 were excluded from this table because there were no unacceptable risks from groundwater.
b	ICs for all alternatives will be applied to all redevelopment blocks, parcelwide. Institutional controls for vapor controls will be applied to all redevelopment blocks, except Redevelopment Block 4.
COC	Chemical of concern
IC	Institutional control
IR	Installation Restoration
VOC	Volatile organic compound
ZVI	Zero-valent iron

TABLE 5-3: GROUNDWATER MONITORING WELLS, ANALYTES, AND RATIONALE
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Monitoring Well	Analyte[a]	Rationale
IR07MWS-2	Lead	Monitor concentration of lead observed in 2004
IR07MW20A1	Copper	Monitor concentration of copper observed in 1991 at former well IR07MW20A2
IR10MW13A1	VOC	Monitor reduction of VOC concentrations in IR-10A VOC plume
IR10MW28A	VOC	Monitor reduction of VOC concentrations in IR-10A VOC plume
IR10MW31A1	VOC	Monitor possible migration of IR-10A VOC plume
IR10MW32A	VOC, Cr VI	Monitor possible migration of IR-10A VOC plume and IR-10B chromium VI plume
IR10MW33A	VOC	Monitor reduction of VOC concentrations in IR-10A VOC plume
IR10MW59A	VOC	Monitor possible migration of IR-10A VOC plume
IR10MW61A	VOC	Monitor reduction of VOC concentrations in IR-10A VOC plume
IR10MW62A	VOC	Monitor possible migration of IR-10A VOC plume
IR10MW63A	VOC	Monitor reduction of VOC concentrations in IR-10A VOC plume
IR10MW71A	VOC	Monitor reduction of VOC concentrations in IR-10A VOC plume
IR10MW76A	VOC	Monitor possible migration of IR-10A VOC plume
IR10MW79A	VOC	Monitor possible migration of IR-10A VOC plume
IR10MW80A	VOC	Monitor possible migration of IR-10A VOC plume
IR10MW81A	VOC, Cr VI	Monitor possible migration of IR-10A VOC plume and IR-10B chromium VI plume (replaced well PA50MW01A that was decommissioned during the radiological removal action)
IR10MW82A	VOC, Cr VI	Monitor possible migration of IR-10A VOC plume and IR-10B chromium VI plume (replaced well IR10MW12A that was decommissioned during the radiological removal action)
IR20MW17A	VOC	Monitor possible migration of IR-25 VOC plume and 1,2-dichloroethene and benzene concentrations observed in 1994
IR24MW06A	VOC	Monitor possible migration of IR-25 VOC plume and TCE concentration observed in 1995 at former well IR24MW04A
IR25MW61A1	VOC	Monitor possible migration of IR-25 VOC plume and chloroform concentration observed in 2004
IR25MW61A2	VOC	Monitor possible migration of IR-25 VOC plume and chloroform concentration observed in 2004

TABLE 5-3: GROUNDWATER MONITORING WELLS, ANALYTES, AND RATIONALE (CONTINUED)
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Monitoring Well	Analyte[a]	Rationale
IR26MW41A	VOC	Monitor concentrations of dichlorodifluoromethane observed in 2004
IR26MW46A	VOC, Mercury	Monitor mercury concentrations near San Francisco Bay and concentration of chloroform observed at former well IR26MW45A
IR26MW47A	VOC, Mercury	Monitor mercury concentrations near San Francisco Bay and concentration of chloroform observed at former well IR26MW45A
IR26MW48A	VOC, Mercury, Lead	Monitor mercury concentrations near San Francisco Bay, concentration of chloroform observed at former well IR26MW45A, concentration of lead observed in 2004 at well IR26MW48A
IR26MW49A	VOC, Mercury	Monitor mercury concentrations near San Francisco Bay and concentration of chloroform observed at former well IR26MW45A
IR26MW50A	VOC, Mercury	Monitor mercury concentrations near San Francisco Bay and concentration of chloroform observed at former well IR26MW45A
New well at IR-26	VOC, Mercury	Monitor mercury concentrations near San Francisco Bay and concentration of chloroform observed at former well IR26MW45A; this well to be installed in the area of mercury source removal after the remedial action work
IR61MW05A	VOC, Cr VI	Monitor possible migration of IR-10A VOC plume and IR-10B chromium VI plume
PA50MW02A	Mercury	Monitor concentration of mercury observed in 1994
UT03MW11A	VOC	Monitor concentration of PCE observed at former well IR07MWS-1

Notes

a The Navy is implementing an adaptable strategy for groundwater monitoring based on the Triad approach to allow flexibility to optimize monitoring. This strategy may be included in the future design of the groundwater monitoring program, and may result in changes to the proposed monitoring wells and analytes presented above.

Cr VI Hexavalent chromium
IR Installation Restoration
PCE Tetrachloroethene
TCE Trichloroethene
VOC Volatile organic compound

6.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

This section provides a detailed analysis of each remedial alternative developed in Section 5.0. This section also includes a detailed analysis of the remediation alternatives selected in the 1997 ROD which highlights the need to reevaluate the remedy. This information will be used to help select a final remedy for Parcel B. The alternatives are evaluated using criteria based on the statutory requirements of CERCLA as amended by the Superfund Amendments and Reauthorization Act, Section 121; the NCP; and "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA 1988b).

This section further considers the remediation alternatives selected in the 1997 ROD (Navy 1997) and how the alternatives would rank in comparison to the two threshold and five balancing NCP evaluation criteria based on the updated information about Parcel B. Updated information includes items such as the ubiquitous nature of metals in soil across Parcel B, the presence of methane and mercury, the findings of the SLERA, changes in toxicity criteria, and findings from removal actions to address radiological contaminants.

The NCP specifies nine criteria to be used in the comparative analysis. The first two are threshold criteria that must be satisfied for a remedy to be eligible for selection; the next five are balancing criteria used to evaluate the comparative advantages and disadvantages of the remedies; and the final two are modifying criteria generally taken into account after agency and public comments are received on the proposed plan. The nine criteria are listed below.

Overall protection of human health and the environment: This criterion describes how each alternative, as a whole, protects human health and the environment and indicates how each hazardous substance source is to be eliminated, reduced, or controlled.

Compliance with ARARs: This criterion evaluates each alternative's compliance with ARARs, or, if an ARAR waiver is required, how the waiver is justified. ARARs consider location-specific, chemical-specific, and cleanup action-specific concerns.

Long-term effectiveness and permanence: This criterion evaluates the effectiveness of each alternative in protecting human health and the environment after the remedial action is complete. Factors considered include magnitude of residual risks and adequacy and reliability of release controls.

Reduction of toxicity, mobility, or volume through treatment: This criterion evaluates the anticipated capability of each alternative's specific treatment technology to reduce the toxicity, mobility, or volume of hazardous substances.

Short-term effectiveness: This criterion addresses the effectiveness of each alternative in protecting human health and the environment during the construction and implementation phase. Factors considered include:

- Exposure of the community during implementation
- Exposure of the workers during construction
- Environmental impacts
- Time required to complete the remedial action and achieve RAOs

Implementability: This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of the required services and materials during its implementation. Factors considered include:

- Ability to construct the technology
- Reliability of the technology
- Monitoring considerations
- Availability of equipment and specialists

Cost: This criterion evaluates the capital and operation and maintenance (O&M) costs for each alternative. Capital and O&M cost estimates are order-of-magnitude level estimates and have an expected accuracy of minus 30 to plus 50 percent (EPA 2000b). Table 6-1 summarizes the capital cost for each alternative.

Community Acceptance: This criterion evaluates issues and concerns the public may have about each alternative. This criterion will be assessed after community comments have been received on the TMSRA and the proposed plan.

Regulatory Agency Acceptance: This criterion evaluates technical and administrative issues and concerns the regulatory agencies may have about each alternative. This criterion will be assessed after agency comments are received on the TMSRA and the proposed plan.

In the following sections, each remedial alternative and the original ROD alternatives are evaluated in comparison to the two threshold and five balancing NCP criteria, and subsequently compared with other alternatives to assess the relative performance with respect to these criteria. The two modifying criteria of community and regulatory acceptance will be compared in the updated proposed plan and ROD amendment for Parcel B; these criteria are not discussed further in this section. Remedial alternatives for soil are evaluated individually in Section 6.1 and compared with each other in Section 6.2. Groundwater remedial alternatives are evaluated individually in Section 6.3 and compared with each other in Section 6.4.

6.1 INDIVIDUAL ANALYSIS OF SOIL REMEDIAL ALTERNATIVES

This section evaluates each soil alternative, including the original ROD alternative, in comparison to the two threshold and five balancing NCP evaluation criteria. Table 6-1 presents the cost summary for each alternative, and Table 6-2 provides a summary of each alternative's rating under the seven evaluation criteria. The ranking categories used in Table 6-2 and in the discussion of the alternatives are (1) protective or not protective, and meets ARARs or does not meet ARARs, for the two threshold criteria; and (2) excellent, very good, good, poor, and not acceptable for the five balancing criteria.

6.1.1 Individual Analysis of Alternative S-1

Under Alternative S-1, no remedial action will be taken. Soil at Parcel B will be left in place as is, without implementing any institutional controls, containment, removal, treatment, or other response actions. The no-action response is retained throughout the evaluation process as required by the NCP to provide a baseline for comparison with other alternatives. As discussed below, the overall rating of Alternative S-1 is not acceptable.

Table 6-2 summarizes the analysis of Alternative S-1 relative to the evaluation criteria.

6.1.1.1 Overall Protection of Human Health and the Environment: Alternative S-1

COCs at Parcel B pose unacceptable risks to human health under the proposed planned reuse for several redevelopment blocks. Alternative S-1 does not address these risks; therefore, the rating for Alternative S-1 for overall protection of human health and the environment is not protective.

6.1.1.2 Compliance with ARARs: Alternative S-1

There is no need to identify ARARs for the no-action alternative because ARARs apply to "any removal or remedial action conducted entirely on-site" and "no action" is not a removal or remedial action. CERCLA § 121 (42 U.S.C. § 9621) cleanup standards for selection of a Superfund remedy, including the requirement to meet ARARs, are not triggered by the no-action alternative (EPA 1991). Therefore, a discussion of compliance with ARARs is not appropriate for this alternative.

6.1.1.3 Long-Term Effectiveness and Permanence: Alternative S-1

The factors evaluated under long-term effectiveness and permanence included the magnitude of residual risks and the adequacy and reliability of the controls. Under the no-action alternative, residual soils contamination above remediation goals have not been addressed. No controls to prevent exposure and no long-term management measures such as institutional controls are implemented. Based on this evaluation, the overall rating for Alternative S-1 for long-term effectiveness and permanence is not acceptable.

6.1.1.4 Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative S-1

Alternative S-1 does not include treatment that would result in the destruction, transformation, or irreversible reduction in contaminant mobility. Therefore, the overall rating for Alternative S-1 for the reduction of toxicity, mobility, and volume through treatment is poor.

6.1.1.5 Short-Term Effectiveness: Alternative S-1

Four factors are considered as part of the short-term effectiveness criteria and are assessed below for Alternative S-1.

No remedial actions would occur and the on-site community would not be exposed to additional risks from soil; the risks would be as presented in the risk assessment. The off-site community would be protected, as soils that present unacceptable risk would not be disturbed.

No workers would be exposed to health risks during implementation of Alternative S-1 because no remedial action will be taken.

No adverse environmental impacts would result from construction and implementation of Alternative S-1 because no remedial action will be taken.

Because no remedial action will be taken, no time would be required to complete Alternative S-1. However, time is an inappropriate measure because no action is taken.

The overall rating for Alternative S-1 for short-term effectiveness is very good based on no additional risks or exposure as compared with current conditions.

6.1.1.6 Implementability: Alternative S-1

Implementability includes technical and administrative feasibility and the availability of required resources. No action, including implementing institutional controls or constructing and operating a remedial system, would be required to implement this alternative; therefore, Alternative S-1 would be very easily implemented, and the overall rating for Alternative S-1 for implementability is excellent.

6.1.1.7 Cost: Alternative S-1

No capital or O&M costs are associated with Alternative S-1; therefore, the overall rating for Alternative S-1 for cost is excellent.

6.1.1.8 Overall Rating: Alternative S-1

The overall rating for Alternative S-1 is not acceptable because it fails to meet the threshold criteria and is not acceptable in terms of long-term effectiveness.

6.1.2 Individual Analysis of Alternative S-2

Alternative S-2 consists of institutional controls, maintained landscaping, and construction of a shoreline revetment. Institutional controls are described in detail in Section 4.3. The overall rating for Alternative S-2 is good.

Table 6-2 summarizes the analysis of Alternative S-2 relative to the evaluation criteria.

6.1.2.1 Overall Protection of Human Health and the Environment: Alternative S-2

Concentrations of COCs in soil above the RAOs present a potential unacceptable risk to human health based on the proposed land-use scenario. Alternative S-2 provides protection to human health and the environment by preventing land-use changes and restricting access to potential exposure areas, thereby preventing receptor exposure to contaminated soil at Parcel B. Signs and fences would prevent human receptors from entering areas where they could contact soils before the area is developed. Areas of bare or minimally vegetated soil that have been disturbed by excavation or construction (primarily from the radiological removal actions) and have not been restored with a cover will be covered by maintained landscaping to prevent potential exposure to asbestos. After development, institutional controls would prevent contact with the soil. The shoreline revetment would prevent erosion and migration of contaminated soil or sediment into San Francisco Bay. The rating for Alternative S-2 for the overall protection of human health and the environment is protective.

6.1.2.2 Compliance with ARARs: Alternative S-2

Alternative S-2 includes both institutional controls and remedial actions. Both action- and chemical-specific ARARs associated with this alternative would be met. The location-specific ARARs identified for the coastal zone and activities at Parcel B that affect San Francisco Bay would also be met. As a result, Alternative S-2 would meet ARARs.

6.1.2.3 Long-Term Effectiveness and Permanence: Alternative S-2

The factors evaluated under long-term effectiveness and permanence included the magnitude of residual risks and the adequacy and reliability of controls. Under Alternative S-2, institutional controls prevent a complete exposure pathway to all potential human receptors. The adequacy and reliability of this alternative would be good, depending on maintenance of the ground controls (fences, barriers, signs, and maintained landscaping) and the degree of enforcement.

The long-term effectiveness of the shoreline revetment would be very good, depending on the adequacy of maintenance. The overall rating for Alternative S-2 for long-term effectiveness and permanence is good.

6.1.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative S-2

Alternative S-2 includes institutional controls, maintained landscaping, and shoreline revetment. This alternative does not include treatment that would result in the destruction, transformation, or irreversible reduction in contaminant mobility. Therefore, the overall rating for Alternative S-2 for the reduction of toxicity, mobility, and volume through treatment is poor.

6.1.2.5 Short-Term Effectiveness: Alternative S-2

Four factors are considered as part of the short-term effectiveness criteria and are assessed below for Alternative S-2.

The on-site and off-site community would be protected because soils that pose an unacceptable risk would not be significantly disturbed during implementation of institutional controls. The community would be protected during construction of the shoreline revetment by implementing containment controls, such as dust suppression, during construction.

Barriers, fences, signs, and maintained landscaping would be constructed and maintained for Alternative S-2. Minimal exposure to workers would occur during construction of fences and maintained landscaping. Some existing fences would be used. However, most of the fencing would be around the perimeter of the areas of exposed soil, and health and safety requirements and personal protective equipment protocols would be enforced to minimize the exposure risk. Likewise, health and safety requirements, personal protective equipment, and best management practices for construction of maintained landscaping and the shoreline revetment would help ensure that effects on workers would be minimal.

Construction efforts for Alternative S-2 are minimal for institutional controls and moderate for the shoreline revetment. Parcel B does not contain terrestrial habitat. Best management practices under the basewide storm water management plan would prevent soil from reaching the bay during construction of fences and implementation of covers under institutional controls. Standard construction practices would be modified along the shoreline to minimize potential effects on the bay. These practices could include construction at low tide and using long-reach equipment. Knowledge the Navy gained during activities along the Parcel E shoreline would be applied to Parcel B to minimize any impact on the bay during construction.

The estimated time required to implement Alternative S-2 is approximately 6 months, and the effects of implementing this alternative would be nearly immediate.

The overall rating for Alternative S-2 for short-term effectiveness is good.

6.1.2.6 Implementability: Alternative S-2

Implementability includes technical and administrative feasibility and the availability of required resources. Minimal construction and maintenance operations would be required to implement the institutional control and maintained landscaping portions of Alternative S-2; the shoreline revetment portion of the alternative is technically feasible and relatively easily implemented because construction would use conventional technologies. In addition, the administrative aspects of the institutional controls associated with this alternative would be straightforward to implement. The overall rating for Alternative S-2 for implementability is very good.

6.1.2.7 Cost: Alternative S-2

The total capital and O&M costs for Alternative S-2 are presented in Table 6-1 and are detailed in Appendix D. The overall rating for Alternative S-2 for cost is excellent; costs are about 50 percent of the most expensive alternative.

6.1.2.8 Overall Rating: Alternative S-2

The overall rating for Alternative S-2 is good. Threshold criteria are met, the institutional controls require prevention of exposure pathways for all COCs, and the shoreline revetment prevents exposure to contaminated sediment.

6.1.3 Individual Analysis of Alternative S-3

As discussed in Section 5.2.3, Alternative S-3 consists of (1) excavation and disposal of contaminated soil (including the mercury source), (2) excavation and disposal of soil and debris in the methane source area, (3) institutional controls, fences, and maintained landscaping to prevent exposure to COCs in soils that are left in place, and (4) construction of a shoreline revetment. Table 6-2 summarizes the analysis of Alternative S-3 relative to the evaluation criteria. The overall rating for Alternative S-3 is good.

6.1.3.1 Overall Protection of Human Health and the Environment: Alternative S-3

Alternative S-3 provides protection to human health and the environment because it would remove soil contaminated with organic compounds (including excavation of the methane source area) mercury, and lead that presents unacceptable risk for the planned reuse. The shoreline revetment would prevent exposure to contaminated sediment. Areas of bare or minimally vegetated soil that have been disturbed by excavation or construction (primarily from the radiological removal actions) and have not been restored with a cover will be covered by maintained landscaping to prevent potential exposure to asbestos. All other areas with unacceptable risk based on planned reuse would be mitigated by implementing institutional controls. Areas where soil would be removed would have an excellent overall protection rating. Therefore, the overall rating for Alternative S-3 for overall protection of human health and the environment is protective.

6.1.3.2 Compliance with ARARs: Alternative S-3

Alternative S-3 includes both institutional controls and remedial actions. Both action- and chemical-specific ARARs associated with this alternative would be met. The location-specific ARARs identified for the coastal zone and activities at Parcel B that affect San Francisco Bay would also be met. As a result, Alternative S-3 would meet ARARs.

6.1.3.3 Long-Term Effectiveness and Permanence: Alternative S-3

The factors evaluated under long-term effectiveness and permanence included the magnitude of residual risks and the adequacy and reliability of controls. Under Alternative S-3, contaminated soil in excavated areas would be removed and disposed of off site. Excavation would continue until results of confirmation samples indicate remediation goals are met or until the excavation would extend to a depth of 10 feet bgs in residential and industrial reuse areas, and 2 feet bgs in recreational reuse areas except for source removal excavations. The excavation for methane source removal may extend below 10 feet bgs, depending on the location of the source material; the excavation for mercury source removal will extend below 10 feet bgs to the top of bedrock. Areas that have ubiquitous metals at concentrations above remediation goals would be addressed by implementing institutional controls. Long-term effectiveness and permanence in areas where organic compounds, mercury, and lead would be excavated are rated as excellent. The adequacy and reliability of this alternative are good in areas where only institutional controls are used. Institutional controls depend on maintenance of ground controls (fences, barriers, signs, and maintained landscaping) and degree of enforcement. The long-term effectiveness of the shoreline revetment would be very good, depending on the adequacy of maintenance. The overall rating for Alternative S-3 for long-term effectiveness and permanence is very good.

6.1.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative S-3

Alternative S-3 includes excavation of contaminated soil, methane and mercury source removal, maintained landscaping, shoreline revetment, and institutional controls. However, this alternative does not include treatment that would result in the destruction, transformation, or irreversible reduction in contaminant mobility. Therefore, the overall rating for Alternative S-3 for the reduction of toxicity, mobility and volume through treatment is poor.

6.1.3.5 *Short-Term Effectiveness: Alternative S-3*

Four factors are considered as part of the short-term effectiveness criteria and are assessed below for Alternative S-3.

The community would be protected by implementing containment controls such as dust suppression during excavation and construction of the shoreline revetment and covers over the hauling trucks during off-site transportation.

Workers would be protected during soil excavation and construction of the shoreline revetment by implementing containment controls, such as dust suppression during excavation, stockpiling and loading trucks, and following health and safety protocols, including personal protective equipment and decontamination procedures. As with Alternative S-2, the institutional controls would require installing barriers, fences, and signs, and health and safety requirements and personal protective equipment protocols would be enforced to minimize worker exposure during these activities.

Construction efforts for the soil removal involve five areas to be excavated and a moderate volume to be removed; therefore, the adverse environmental impacts from removal and disposal would be moderate. The construction efforts for implementing the institutional controls for Alternative S-3 are nearly the same as for Alternative S-2. Best management practices for construction will ensure that effects would be minimal. Similar to Alternative S-2, standard construction practices would be modified along the shoreline and knowledge gained by the Navy at Parcel E would be used to minimize potential effects on the bay during construction of the shoreline revetment.

The estimated time required to implement Alternative S-3 is less than 1 year, and the effects of implementing this alternative are nearly immediate.

The overall rating for Alternative S-3 for the short-term effectiveness is good.

6.1.3.6 *Implementability: Alternative S-3*

Implementability includes technical and administrative feasibility and the availability of required resources. The alternative is technically feasible and easily implemented because excavation and hauling are considered conventional and commonplace technologies; construction of the shoreline revetment is also technically feasible and relatively easily implemented. In addition, the institutional controls proposed for this alternative are easy to implement administratively. The overall rating for Alternative S-3 for implementability is very good.

6.1.3.7 Cost: Alternative S-3

The total capital and O&M costs and the parameters used to derive present worth costs for Alternative S-3 are presented in Table 6-1 and are detailed in Appendix D. The overall rating for Alternative S-3 for cost is good.

6.1.3.8 Overall Rating: Alternative S-3

The overall rating for Alternative S-3 is good. Institutional controls prevent exposure to all COCs, long-term exposure to organic compounds, mercury, and lead is reduced through excavation, and the shoreline revetment prevents exposure to contaminated sediment.

6.1.4 Individual Analysis of Alternative S-4

Alternative S-4 includes (1) covers over all redevelopment blocks to prevent human exposure to ubiquitous metals that may pose an unacceptable risk, (2) excavation and disposal of soil and debris in the methane and mercury source areas, (3) institutional controls, including maintaining the covers, and (4) construction of a shoreline revetment.

Table 6-2 summarizes the analysis of Alternative S-4 relative to the evaluation criteria. The overall rating for Alternative S-4 is very good.

6.1.4.1 Overall Protection of Human Health and the Environment: Alternative S-4

Alternative S-4 provides protection to human health and the environment because soils that pose unacceptable risk based on planned future land use and soil with ubiquitous metals would be covered. These covers would be implemented over the entire redevelopment block. The institutional controls further require maintenance of the covers parcel-wide. These covers will prevent exposure to all chemicals in soil. This alternative is also protective of human health and the environment through the use of institutional controls that restrict reuse of the redevelopment blocks to activities that would not present a potential unacceptable risk. Similar to Alternative S-3, Alternative S-4 provides protection of human health and the environment because it would remove soil contaminated with organic compounds in the methane source area and mercury in the mercury source area. The shoreline revetment would prevent exposure to contaminated sediment. The rating for Alternative S-4 for overall protection of human health and the environment is protective.

6.1.4.2 Compliance with ARARs: Alternative S-4

Alternative S-4 consists of containment mitigation using covers and the shoreline revetment, excavation, and institutional controls. Action- and chemical-specific ARARs associated with this alternative would be met. The location-specific ARARs identified for, the coastal zone and activities at Parcel B that affect San Francisco Bay would also be met. As a result, Alternative S-4 would meet the ARARs.

6.1.4.3 Long-Term Effectiveness and Permanence: Alternative S-4

The factors evaluated under long-term effectiveness and permanence included the magnitude of residual risks and the adequacy and reliability of controls. Under Alternative S-4, risks associated with exposure to COCs and ubiquitous metals in soil are mitigated by covering the soils. The Navy proposes to use covers over all redevelopment blocks (informally termed "full lot coverage"). As a result, the exposure pathways are cut off. The adequacy and reliability of the institutional controls depend on monitoring and maintenance of the covers, but are overall expected to be very good. Similar to Alternative S-3, long-term effectiveness and permanence in addressing the methane and mercury source areas is rated as excellent. The long-term effectiveness of the shoreline revetment would be very good, depending on the adequacy of maintenance. The overall rating for Alternative S-4 for long-term effectiveness and permanence is very good.

6.1.4.4 Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative S-4

Alternative S-4 includes covers over contaminated soil, excavation, methane and mercury source removal, shoreline revetment, and institutional controls. However, this alternative does not include treatment that would result in the destruction, transformation, or irreversible reduction in contaminant mobility. Therefore, the overall rating for Alternative S-4 for the reduction of toxicity, mobility, and volume through treatment is poor.

6.1.4.5 Short-Term Effectiveness: Alternative S-4

Four factors are considered as part of the short-term effectiveness criteria and are assessed below for Alternative S-4.

Risks to the community and current occupants may occur from the increased construction traffic. Only tested soil or asphalt would be imported to construct the covers, and trucks would cover the loads and adhere to a traffic plan that mitigates noise and traffic concerns of the community. Much of Parcel B is already covered with buildings, asphalt, or concrete, and repairs to these covers would cause minimal disturbance and impact to the community. The community would be protected by implementing containment controls such as dust suppression during excavation and construction of the shoreline revetment, and covers over the hauling trucks during off-site transportation.

Risk to workers who are constructing covers over known contaminated soil may occur. However, workers would adhere to a chemical- and activity-specific health and safety plan, which would include personal protective equipment and protective exposure measures. Workers would be protected during soil excavation and construction of the shoreline revetment by implementing containment controls, such as dust suppression during excavation, stockpiling and loading trucks, and following health and safety protocols, including personal protective equipment and decontamination procedures.

Environmental impacts during construction would be mitigated with effective work practices. Parcel B does not contain terrestrial habitat. Best management practices for construction will prevent soil from reaching the bay during construction. Similar to Alternative S-2, standard construction practices would be modified along the shoreline and knowledge gained by the Navy at Parcel E would be used to minimize potential effects on the bay during construction of the shoreline revetment.

There would be a little impact from the time required to complete the remedial action because the activities would likely be completed in 1 year or less. The effects of implementing the alternative would be nearly immediate.

The overall rating for Alternative S-4 for short-term effectiveness, including implementing the institutional controls, is very good.

6.1.4.6 Implementability: Alternative S-4

Implementability includes technical and administrative feasibility and the availability of required resources. The alternative is technically feasible and easily implemented because excavation and hauling, grading and installing covers, and repairing and monitoring existing concrete and asphalt covers are conventional and commonplace technologies. Fences and signs are not required for Alternative S-4, improving the ease of movement and use of Parcel B before development. Construction of the shoreline revetment is also technically feasible and relatively easily implemented. In addition, the institutional controls are administratively easy to implement. The overall rating for Alternative S-4 for implementability is very good.

6.1.4.7 Cost: Alternative S-4

The total capital and O&M costs for Alternative S-4 are presented in Table 6-2 and are detailed in Appendix D. The overall rating for Alternative S-4 for cost is good.

6.1.4.8 Overall Rating: Alternative S-4

The overall rating for Alternative S-4 is very good. Institutional controls prevent exposure to all COCs. Short-term exposure is reduced through soil covers for all redevelopment blocks with unacceptable risk. Long-term exposure to organic compounds at the methane source area and mercury at the mercury source area is reduced through excavation, and the shoreline revetment prevents exposure to contaminated sediment.

6.1.5 Individual Analysis of Alternative S-5

Alternative S-5 combines the excavation and off-site disposal and soil covers of Alternatives S-3 and S-4 to remediate redevelopment blocks where a potential unacceptable risk occurs because of contaminated soils based on planned land use. Alternative S-5 also includes operation of an SVE system to remove and treat VOCs in soil at Redevelopment Block 8, construction of shoreline revetment, and implementation of institutional controls. The overall protectiveness of the alternative is increased because it uses both removal, containment, and treatment approaches. Alternative S-5 would involve removal of soils with organic compounds, mercury, and lead that pose a potential unacceptable risk and covers over all redevelopment blocks to prevent human exposure to ubiquitous metals that may pose a potential unacceptable risk. The institutional controls for Alternative S-5 would be implemented to maintain covers parcel-wide and restrict the land uses that may cause a potential unacceptable risk after the remedy is implemented.

Table 6-2 summarizes the analysis of Alternative S-5 relative to the evaluation criteria. The overall rating for Alternative S-5 is excellent.

6.1.5.1 Overall Protection of Human Health and the Environment: Alternative S-5

Alternative S-5 provides the best protection to human health and the environment compared with other alternatives for soil because soil contaminated with organic compounds (including the methane source area), mercury, and lead that poses potential unacceptable risk would be removed or treated (at Redevelopment Block 8), and all other soils parcel-wide would be covered. Institutional controls for this alternative would also be protective of human health and the environment because they will ensure covers are maintained parcel-wide. Institutional controls would require that land uses defined in the ROD amendment be maintained, preventing exposure pathways outside of the planned reuse. The shoreline revetment would prevent exposure to contaminated sediment. The rating for Alternative S-5 for the overall protection of human health and the environment is protective.

6.1.5.2 Compliance with ARARs: Alternative S-5

Alternative S-5 consists of removal, containment, treatment, and institutional controls. Action- and chemical-specific ARARs are associated with this alternative and would be met. The location-specific ARARs identified for the coastal zone and activities at Parcel B that affect San Francisco Bay would also be met. As a result, Alternative S-5 would meet ARARs.

6.1.5.3 *Long-Term Effectiveness and Permanence: Alternative S-5*

The factors evaluated under long-term effectiveness and permanence included the magnitude of residual risks and the adequacy and reliability of controls. Under Alternative S-5, soils with organic compounds, mercury, and lead that pose a potential unacceptable risk would be removed or treated (using SVE for VOCs at Redevelopment Block 8). In addition, residual risks from other COCs would be mitigated through the use of covers that prevent the exposure pathways. The adequacy and reliability of the institutional controls depend on monitoring and maintenance of the covers to continue their effectiveness. The long-term effectiveness and permanence of SVE is expected to be very good based on the results of pilot tests in the area to be treated. The long-term effectiveness of the shoreline revetment would be very good, depending on the adequacy of maintenance. The overall rating for Alternative S-5 for long-term effectiveness and permanence is excellent.

6.1.5.4 *Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative S-5*

Alternative S-5 includes covers over contaminated soil, excavation, methane and mercury source removal, SVE, shoreline revetment, and institutional controls. However, except for the SVE portion, this alternative does not include treatment that would result in the destruction, transformation, or irreversible reduction in contaminant mobility. The SVE system would reduce the volume of VOCs in soil at Redevelopment Block 8 through treatment. The overall rating for Alternative S-5 for the reduction of toxicity, mobility, or volume through treatment is good.

6.1.5.5 *Short-Term Effectiveness: Alternative S-5*

Four factors are considered as part of the short-term effectiveness criteria and are assessed below for Alternative S-5.

Risks to the community and current occupants may occur by excavating and transporting contaminated soils off site; however, these risks would be minimized by implementing containment controls, such as dust suppression during excavation and covers over the hauling trucks during off-site transportation. Alternative S-5 would also pose added risks to the community and current occupants by increased construction traffic. Clean soil or asphalt would be imported to backfill the excavations and construct the covers; however, the hauling trucks would cover the loads and adhere to a traffic plan that mitigates noise and traffic concerns of the community.

Risks to workers that are excavating and hauling soil and constructing covers or the shoreline revetment over known contaminated soil would require mitigation. Risks to worker constructing the SVE system at Redevelopment Block 8 also would require mitigation. All of the workers would adhere to a chemical- and activity-specific health and safety plan, which would include personal protective equipment, decontamination procedures, and protective exposure measures.

Adverse environmental impacts from removal and disposal may occur because of disrupting soil and raising fugitive dust. Soil removals would involve five areas and a moderate volume of soil. Much of Parcel B already contains existing covers, so that there is no existing terrestrial habitat within Parcel B; therefore, the adverse environmental impacts from implementing the covers would be low. Best management practices for construction would prevent soil from reaching the bay during construction. Similar to Alternative S-2, standard construction practices would be modified along the shoreline and the knowledge gained by the Navy at Parcel E would be used to minimize potential effects on the bay during construction of the shoreline revetment.

The time required to complete the remedial action is less than 1 year, and the effects of implementing this alternative would be nearly immediate.

The overall rating for Alternative S-5 for short-term effectiveness, including implementing the institutional controls, is very good.

6.1.5.6 Implementability: Alternative S-5

Implementability includes technical and administrative feasibility and the availability of required resources. Alternative S-5 would be technically feasible and easily implemented because excavating, hauling, backfilling, grading, installing covers, and repairing existing concrete and asphalt covers are conventional and commonplace technologies. Construction of the SVE system and the shoreline revetment are also technically feasible and relatively easy to implement. In addition, the institutional controls are easy to implement administratively. The overall rating for Alternative S-5 for implementability is very good.

6.1.5.7 Cost: Alternative S-5

The total capital and O&M costs for Alternative S-5 are presented in Table 6-1 and are detailed in Appendix D. Alternative S-5 is the most expensive soil alternative (about 5 percent more than Alternative S-4). The overall rating for Alternative S-5 for costs is good.

6.1.5.8 Overall Rating: Alternative S-5

The overall rating for Alternative S-5 is excellent. Exposure to COCs and all chemicals in soil is prevented with soil covers. Organic chemicals are removed by excavation and disposal or are treated using SVE. Mercury and lead are removed by excavation. Long-term protectiveness is provided with institutional controls. The shoreline revetment prevents exposure to contaminated sediment.

6.1.6 Individual Analysis of Original ROD Soil Remediation Alternative

The original ROD remedy for soil includes (1) excavation and disposal of contaminated soil, and (2) institutional controls to prevent exposure to COCs in soils that are left in place (below the maximum excavation depth). The following evaluation considers the rating of the remedial action if it were resumed and completed according to the cleanup goals in the ROD.

6.1.6.1 Overall Protection of Human Health and the Environment: Original ROD Soil Alternative

The original ROD alternative did not consider excavation below 10 feet bgs and it is likely that deeper excavation would be necessary to remove the source of methane at IR-07 and deeper excavation would be necessary to remove the source of mercury at IR-26. In addition, radiological contamination is present at Parcel B that was not known when the ROD was prepared. Therefore, the rating for the original ROD alternative for overall protection of human health and the environment would be not protective based on the sources of methane and mercury remaining in place and the radiological contamination.

6.1.6.2 Compliance with ARARs: Original ROD Soil Alternative

Chemical-specific ARARs associated with this alternative would not be met based on concentrations of methane detected in soil gas. Therefore, the original ROD alternative would not meet ARARs.

6.1.6.3 Long-Term Effectiveness and Permanence: Original ROD Soil Alternative

The factors evaluated under long-term effectiveness and permanence included the magnitude of residual risks and the adequacy and reliability of controls. Under the original ROD alternative, contaminated soil in excavated areas would be removed and disposed of off site. Excavation would continue until results of confirmation samples indicate that remediation goals are met or until the excavation would extend to a depth of 10 feet bgs. Long-term effectiveness and permanence in areas where COCs are excavated is rated as excellent; however, excavation of most of the bedrock fill and all of the debris fill area would be required to remove all COCs. Excavation would not address the methane and mercury sources because the source likely extends below 10 feet bgs. The rating for the original ROD alternative for long-term effectiveness and permanence is poor based on the sources of methane and mercury that would remain in place.

6.1.6.4 Reduction of Toxicity, Mobility, or Volume through Treatment: Original ROD Soil Alternative

The original ROD alternative includes excavation of contaminated soil and institutional controls. However, this alternative does not include treatment that would result in the destruction, transformation, or irreversible reduction in contaminant mobility. Therefore, the rating for the original ROD alternative for reduction of toxicity, mobility, or volume through treatment is poor.

6.1.6.5 Short-Term Effectiveness: Original ROD Soil Alternative

Four factors — effects on the community, worker protection, adverse environmental impacts, and time to complete — are considered as part of the short-term effectiveness criterion and are assessed below for the original ROD alternative.

The community would be protected by implementing containment controls such as dust suppression during excavation and covers over the hauling trucks during off-site transportation.

Workers would be protected during soil excavation by implementing containment controls, such as dust suppression during excavation, stockpiling and loading trucks, and following health and safety protocols, including personal protective equipment and decontamination procedures. Institutional controls would require installing barriers, fences, and signs, and health and safety requirements and personal protective equipment protocols would be enforced to minimize worker exposure during these activities.

Construction efforts for the soil removal would involve most of the remaining areas of bedrock fill and all of the remaining debris fill and would include a large volume of material; therefore, the adverse environmental impacts from removal and disposal would be large.

The estimated time required to implement the remaining excavation would be more than 1 year.

The rating for the original ROD alternative for short-term effectiveness is poor.

6.1.6.6 Implementability: Original ROD Soil Alternative

Implementability includes technical and administrative feasibility and the availability of required resources. The alternative is technically feasible because excavation and hauling are considered conventional and commonplace technologies. However, the large scale of the excavation operation and the complexities caused by the existing infrastructure (buildings and subsurface utilities) would decrease the implementability of this alternative. The rating for the original ROD alternative for implementability is poor.

6.1.6.7 Cost: Original ROD Soil Alternative

The cost of the remedial action for soil under the ROD is about $40 million to date (not adjusted to current dollars). This cost would increase substantially for full implementation (removal of most of the remaining bedrock fill and all of the debris fill); cost for full implementation would likely require at least an additional $60 million for a total of more than $100 million. The rating for the original ROD alternative for cost is poor.

6.1.6.8 Overall Rating: Original ROD Soil Alternative

The overall rating for the original ROD soil alternative would be not protective based on (1) the lack of protectiveness because the methane and mercury sources and radiological contamination would remain in place and (2) the lack of compliance with ARARs based on methane detections in soil gas. This low rating is further supported by the poor ranking of the original ROD soil alternative on the five balancing criteria, especially cost.

6.2 COMPARISON OF SOIL REMEDIAL ALTERNATIVES

This section compares the five alternatives for soil developed in the TMSRA and the original soil remedy selected in the ROD. The discussion of each evaluation criterion generally proceeds from the alternative that best satisfies the criterion to the one that least satisfies the criterion. Table 6-2 summarizes the rating for each alternative and shows a comparison of the ratings of each alternative for the two threshold and five balancing NCP evaluation criteria.

6.2.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment is a threshold criterion. Protection is not measured by degree; rather, each alternative is considered as either protective or not protective. Alternatives S-2 through S-5 are protective. Alternative S-5 has excellent overall protection because it includes the most active remediation (using removal, treatment, and containment process options) that reduces potential exposure to contaminated soils. Alternatives S-2 through S-5 protect human health and the environment under the anticipated future land use of the site. Alternative S-1 does not address any risks at the site and hence does not provide any protection to human health and the environment. The original ROD soil alternative would not be protective of human health and the environment in the long term because it does not address the methane and mercury source areas (because they are below 10 feet bgs) and the radiological contamination.

6.2.2 Compliance with Applicable or Relevant and Appropriate Requirements

Compliance with ARARs is a threshold evaluation criterion. An alternative must either comply with ARARs or justification must be provided for a waiver. Alternatives S-2 through S-5 fulfill all the pertinent ARARs. Alternative S-1 and the original ROD soil alternative do not meet ARARs.

6.2.3 Long-Term Effectiveness and Permanence

Alternative S-5 is rated the highest because it includes treatment of VOCs using SVE plus the other effective and permanent technologies from both Alternatives S-3 and S-4. The magnitude of residual risks that would remain after remedial action would be highest for Alternative S-2, which relies on institutional controls to meet the RAOs, and lower for Alternatives S-3 (excavations), S-4 (covers), and S-5 (excavations, covers, and treatment) that reduce the toxicity and volume of contaminants. Alternatives S-2 through S-5 all provide long-term effectiveness in meeting the RAOs because they rely on continuous enforcement of institutional controls to maintain covers and access restrictions. Alternative S-3 provides long-term effectiveness and permanence for soil that contains organic compounds, mercury, and lead that is excavated, but relies on access restrictions for other COCs. Alternative S-4 provides a permanent cover before development, but does not permanently remove any contamination (except for excavations in the methane and mercury source areas). The original ROD soil alternative rates as poor based on the sources of methane and mercury that would remain in place below 10 feet bgs and the radiological contamination. Since no action would be taken under Alternative S-1, it does not provide a long-term effective or permanent solution to the soil and sediment risks present at the site.

6.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternative S-5 would treat VOCs in soil and is the only alternative that provides treatment of contaminants. As a result, Alternative S-5 is rated the highest. Alternatives S-1 through S-4 and the original ROD soil alternative would rate equally poorly because they do not include treatment that would result in the destruction, transformation, or irreversible reduction in contaminant mobility.

6.2.5 Short-Term Effectiveness

Alternative S-1 has the least effect on the community, remedial workers, or the environment because it includes no actions, but will not likely ever reach the RAOs. Alternatives S-2 and S-4 introduce less risk to the community, remedial workers, or the environment because they do not include excavation, hauling, and disposal of contaminated soil. Alternatives S-3, S-5, and the original ROD soil alternative include removing and hauling contaminated soil that would pose potential risk to the community, remedial workers, or the environment, although this risk is considered low and mitigation measures would be implemented. The original ROD soil alternative involves much more excavation than the other alternatives and would pose the most risk to the community, remedial workers, and the environment.

6.2.6 Implementability

Distinction among the alternatives for implementability is minimal. All alternatives require implementation of institutional controls. Installing covers (S-4) and excavating soil (S-3, S-5, and the original ROD soil alternative) are standard technologies that are easy to implement. Alternative S-5 would require the most coordination to implement because it employs the most technologies. The large scale of the excavation operation and complexities caused by the existing infrastructure would decrease the implementability of the original ROD soil alternative. Alternative S-1 does not involve remedial technologies or institutional controls and requires no implementation.

6.2.7 Cost

Alternatives S-1 requires no action; therefore, no costs are associated with this alternative. Alternative S-2 is the least costly ($5.5 million) because it includes only the shoreline revetment as an active remediation component before the property is transferred. Alternative S-3 is estimated to cost approximately $10.7 million, and Alternatives S-4 and S-5 — that include the covers as a process option — are estimated to cost approximately $11.9 million and $12.4 million. The cost for full implementation of the original ROD soil alternative would likely require at least an additional $60 million, for a total of more than $100 million. Estimated capital and O&M costs for each alternative, except the original ROD soil alternative, are summarized in Table 6-1.

6.2.8 Overall Rating of Soil Alternatives

An overall rating was assigned to each alternative (see Table 6-2). Alternative S-5 is rated excellent overall for the two threshold and five balancing NCP evaluation criteria. Alternative S-5 is the most protective, because it includes excavation, treatment, and covers, although it has the highest cost. Alternative S-3, rated good, is more protective than Alternative S-2 because contaminants are removed, although it is somewhat more expensive. Alternative S-4, rated very good, is considerably more expensive, but is more protective than are Alternatives S-2 or S-3 before development. Alternative S-2, rated good, is easiest to implement. Alternative S-1 and the original ROD soil alternative are rated as not protective.

6.3 INDIVIDUAL ANALYSIS OF GROUNDWATER REMEDIAL ALTERNATIVES

This section evaluates each groundwater alternative, including the original ROD alternative, in comparison to the seven evaluation criteria discussed in Section 6.0. Table 6-1 presents the cost summary for each alternative, and Table 6-2 summarizes the rating for each alternative under the two threshold and five balancing NCP evaluation criteria.

6.3.1 Individual Analysis of Alternative GW-1

Under Alternative GW-1, no remedial action would be taken. Groundwater at Parcel B would be left as is, without implementing any institutional controls, containment, removal, treatment, or other response actions. The no action response is retained throughout the evaluation process as required by the NCP to provide a baseline for comparison to and evaluation of other alternatives.

Table 6-2 summarizes the analysis of Alternative GW-1 relative to the evaluation criteria. The overall rating for this alternative is not acceptable.

6.3.1.1 Overall Protection of Human Health and the Environment: Alternative GW-1

Groundwater at Parcel B poses a risk to human health through the vapor intrusion pathway and to ecological receptors through potential migration to San Francisco Bay. Alternative GW-1 does not provide treatment or institutional controls to prevent direct exposure to COCs in groundwater. As a result, Alternative GW-1 is not protective of human health. The rating for Alternative GW-1 for overall protection of human health and the environment is not protective.

6.3.1.2 *Compliance with ARARs: Alternative GW-1*

There is no need to identify ARARs for the no-action alternative because ARARs apply to "any removal or remedial action conducted entirely on-site" and "no action" is not a removal or remedial action. CERCLA § 121 (42 U.S.C. § 9621) cleanup standards for selection of a Superfund remedy, including the requirement to meet ARARs, are not triggered by the no-action alternative (EPA 1991). Therefore, a discussion of compliance with ARARs is not appropriate for this alternative.

6.3.1.3 *Long-Term Effectiveness and Permanence: Alternative GW-1*

The factors evaluated under long-term effectiveness and permanence included the magnitude of residual risks and adequacy and the reliability of controls. Under the no-action alternative, contaminated groundwater that presents a potential unacceptable risk would not be mitigated; therefore, this alternative would present a potential unacceptable risk to human health. The adequacy and reliability of controls are poor because no treatment or institutional controls would be implemented during this alternative. The rating for Alternative GW-1 for long-term effectiveness and permanence is poor.

6.3.1.4 *Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative GW-1*

Alternative GW-1 would not reduce the toxicity, mobility, or volume of hazardous substances at Parcel B because groundwater would not be treated, contained, or removed. The overall rating for Alternative GW-1 for reduction of toxicity, mobility, or volume through treatment is poor.

6.3.1.5 *Short-Term Effectiveness: Alternative GW-1*

Four factors — effects on the community, worker protection, adverse environmental impacts, and time to complete — are considered as part of the short-term effectiveness criterion and are assessed below for Alternative GW-1.

- Because no remedial action will be taken, Alternative GW-1 would not present any new health risks to the community and current occupants.
- No remedial action workers would be exposed to health risks.
- No adverse environmental impacts would result from construction and implementation of Alternative GW-1.
- Alternative GW-1 would not require any implementation time, but would not reach RAOs.

Based on this evaluation, the overall rating for Alternative GW-1 for the short-term effectiveness is very good.

6.3.1.6 *Implementability: Alternative GW-1*

Implementability includes technical and administrative feasibility and the availability of required resources. No construction or operation is required to implement this alternative. As a result, Alternative GW-1 is technically and administratively feasible and does not require any resources. The overall rating for Alternative GW-1 for implementability is excellent.

6.3.1.7 *Cost: Alternative GW-1*

No capital or O&M costs are associated with Alternative GW-1. The rating for Alternative GW-1 for costs is excellent.

6.3.1.8 *Overall Rating: Alternative GW-1*

Alternative GW-1 does not meet the threshold criteria. Therefore, Alternative GW-1 is rated as not acceptable.

6.3.2 Individual Analysis of Alternative GW-2

Alternative GW-2 consists of institutional controls and long-term monitoring. Institutional controls are described in detail in Section 4.3. Institutional controls would be in place to prohibit use of buildings or other enclosures where there is potential unacceptable risk from the vapor intrusion pathway and require engineering controls on all new buildings constructed in redevelopment blocks where groundwater plumes may present potential unacceptable risk from the vapor intrusion pathway.

Monitoring of the A-aquifer for VOCs and metals would continue to occur and would be evaluated using analytical data obtained from a long-term groundwater monitoring program. Details of groundwater monitoring (such as wells to be monitored, analytical suite, laboratory analytical methods, sample collection procedures, and quality control requirements) will be included in the RD that will be prepared after the ROD amendment is completed. Additionally, the Navy is implementing an adaptable strategy for groundwater monitoring based on the Triad approach to allow flexibility to optimize monitoring. This strategy may be included in the future design of the groundwater monitoring program and, if implemented, could change the proposed monitoring wells and analytes presented in the TMSRA. Results of the long-term groundwater monitoring program would be used during the five-year reviews to assess the monitoring program, adjust the requirements for data collection and analysis, and evaluate the need for other response actions. Two groundwater monitoring wells have been installed near well IR26MW47A to monitor concentrations of mercury in groundwater. A third well will be installed within the area of Excavation EE-05 after the final remedy is selected and the mercury source removal is completed.

Table 6-2 summarizes the analysis of Alternative GW-2 relative to the evaluation criteria.

6.3.2.1 Overall Protection of Human Health and the Environment: Alternative GW-2

Alternative GW-2 would protect human health and the environment because it would prevent direct exposure to contaminated groundwater and to vapors through the institutional controls and long-term groundwater monitoring. These institutional controls would prevent exposure of humans to contaminated groundwater; however, active treatment of contamination in the groundwater is not included in this alternative.

The overall rating for Alternative GW-2 for overall protection of human health and the environment is protective.

6.3.2.2 Compliance with ARARs: Alternative GW-2

Chemical-specific ARARs pertinent to Alternative GW-2 would be met by removing the source of mercury and through subsequent groundwater monitoring. The location-specific ARARs identified for activities that would affect San Francisco Bay and the coastal zone at Parcel B would be met. Action-specific ARARs for groundwater monitoring would be met by developing and employing appropriate monitoring protocols. As a result, Alternative GW-2 would meet ARARs.

6.3.2.3 Long-Term Effectiveness and Permanence: Alternative GW-2

The factors evaluated under long-term effectiveness and permanence included the magnitude of residual risks and the adequacy and reliability of controls. Under Alternative GW-2, risks posed by exposure to COCs in groundwater are mitigated by preventing the exposure pathway to potential human receptors. The material in the aquifer matrix that is believed to be a continuing source of mercury in groundwater will be removed as part of the soil remediation alternatives. Groundwater monitoring will be used to evaluate the ongoing effectiveness of the mercury source removal as well as the groundwater treatments undertaken during treatability studies for VOCs. Groundwater monitoring will also be used to evaluate the potential migration of chromium VI, copper, lead, and mercury to the bay. The adequacy and reliability of this alternative depend on (1) the maintenance and enforcement of access restrictions (including installation of vapor controls in new buildings); (2) the reliability of the long-term monitoring program; (3) the completeness of the removal of the mercury source material from the aquifer; and (4) the degree of migration of chromium VI, copper, lead, and mercury. The monitoring parameters would be established in the monitoring program, including appropriately located sentry wells and trigger levels for COCs. Overall, the rating for Alternative GW-2 for long-term effectiveness and permanence is good.

6.3.2.4 Reduction of Toxicity, Mobility, or Volume through Treatment: Alternative GW-2

Alternative GW-2 would not reduce the toxicity, mobility, or volume of contamination through active remediation. The institutional controls for this alternative are intended to prevent exposure to COCs in groundwater. The overall rating for Alternative GW-2 for reducing the toxicity, mobility, or volume through treatment is poor.

6.3.2.5 Short-Term Effectiveness: Alternative GW-2

Four factors are considered as part of the short-term effectiveness criterion and are assessed below for Alternative GW-2.

Alternative GW-2 would not present any new risks to the community and current occupants. Minimal health risks would be posed by the long-term monitoring that would periodically extract and collect small amounts of groundwater for sampling.

No remedial action workers would be exposed to risks because no active remedy to groundwater would be applied. Minimal risk to the workers would be posed during the groundwater monitoring events, but proper personal protective equipment and health and safety protocols would minimize these risks.

No adverse environmental impacts would result from construction and implementation of Alternative GW-2 because no groundwater treatment is proposed. Minimal exposure to groundwater would occur during the long-term groundwater monitoring program.

The institutional controls for Alternative GW-2 would likely be implemented in less than 6 months. Long-term monitoring would extend over 30 years, although the field activities for this monitoring occur for short periods with long intervals of inactivity.

Based on this evaluation, the overall rating for Alternative GW-2 for short-term effectiveness is excellent.

6.3.2.6 Implementability: Alternative GW-2

Implementability includes technical and administrative feasibility and the availability of required resources. No construction or O&M would be required to implement Alternative GW-2; therefore, this alternative is technically and administratively feasible. Long-term groundwater monitoring is a routine activity and requires a moderate level of commonly available resources. The overall rating for Alternative GW-2 for implementability is excellent.

6.3.2.7 *Cost: Alternative GW-2*

The total capital and O&M costs for Alternative GW-2 are presented in Table 6-1 and are detailed in Appendix D. The costs to implement the institutional controls are low, and the cost to implement long-term monitoring is moderate. The overall rating of Alternative GW-2 for cost is very good.

6.3.2.8 *Overall Rating: Alternative GW-2*

Alternative GW-2 meets ARARs and protects human health through institutional controls. The environment is protected with a long-term monitoring program that includes sentry wells to assess migration of groundwater to San Francisco Bay. This alternative is easily implemented with minimal impact to the community. However, it is poor in reducing the toxicity or mobility of contaminants. The overall rating for this alternative is good.

6.3.3 Individual Analysis of Alternatives GW-3A and GW-3B

Alternatives GW-3A and GW-3B consist of implementation of institutional controls, *in situ* injection treatment of the groundwater plumes, and groundwater monitoring during and after *in situ* treatment. The groundwater monitoring is designed to demonstrate the effectiveness of the treatment and would occur for less time as compared with groundwater monitoring under Alternative GW-2. The main difference in Alternatives GW-3A and GW-3B is the treatment additive. The treatment additive for Alternative GW-3A is a bioremediation substrate compound that enhances anaerobic bioremediation by releasing hydrogen. Alternative GW-3B uses ZVI as the treatment additive. Treatment design is similar for Alternatives GW-3A and 3B, with the same well spacing. The volume of ZVI treatment additive is approximately 12 times the amount of the bioremediation substrate. The chemical action of the ZVI in the aquifer is more immediate and quicker than the bioremediation reaction. The advantage of the slower-reacting bioremediation substrate is the continued reaction as the substrate disperses, potentially creating a wider treatment area, and the continued treatment for potential "rebound" conditions. Both approaches are effective, and the primary difference is the total cost of the additives. An additional reagent will be used, as needed, to mitigate dissolved metals in groundwater.

Table 6-2 summarizes the analysis of Alternatives GW-3A and GW-3B relative to the evaluation criteria.

6.3.3.1 *Overall Protection of Human Health and the Environment: Alternatives GW-3A and GW-3B*

Alternatives GW-3A and GW-3B would protect human health and the environment because both accelerate the degradation of contaminants through injection treatment. Both would prevent exposure to contaminated groundwater that may result from unanticipated groundwater uses at the site by implementing institutional controls, as described under Alternative GW-2. The overall rating for Alternatives GW-3A and GW-3B for overall protection of human health and the environment is protective.

6.3.3.2 Compliance with ARARs: Alternatives GW-3A and GW-3B

Chemical-specific ARARs pertinent to Alternatives GW-3A and GW-3B would be met through institutional controls and active treatment of contaminants in groundwater. The location-specific ARARs identified for activities that would affect San Francisco Bay and the coastal zone at Parcel B would also be met. Action-specific ARARs would be met through design of a treatment approach that prevents downward migration of contaminants to an aquifer of drinking water quality. As a result, Alternatives GW-3A and GW-3B would meet ARARs.

6.3.3.3 Long-Term Effectiveness and Permanence: Alternatives GW-3A and GW-3B

The factors evaluated under long-term effectiveness and permanence included the magnitude of residual risks and the adequacy and reliability of controls. Treatability studies at HPS (ERRG and URS 2004; ITSI 2005; Shaw Environmental, Inc. 2005) have demonstrated that in-situ remediation effectively reduces the concentration of VOCs in groundwater. ZVI is effective on vinyl chloride based on the results of groundwater monitoring at IR-10. The same injected chemicals are expected to effectively reduce chromium VI in groundwater to its less toxic form, chromium III. Under Alternatives GW-3A and GW-3B, short-term risks posed by groundwater contamination have been mitigated by preventing a complete exposure pathway to potential human receptors. In addition, the volume and toxicity of contaminated groundwater would be reduced through *in situ* treatment. Mercury source material will be excavated and removed from the site as part of the remediation alternatives for soil. Other dissolved metals (copper and lead) will be treated, as necessary, using an additional reagent. The adequacy and reliability of this alternative depend on the effectiveness of the injected chemicals, the completeness of the removal of the mercury source material, and on maintenance and enforcement of the access restrictions.

The overall rating for Alternative GW-3A for long-term effectiveness and permanence is excellent; the overall rating for Alternative GW-3B for long-term effectiveness and permanence is very good.

6.3.3.4 Reduction of Toxicity, Mobility, or Volume through Treatment: Alternatives GW-3A and GW-3B

Alternatives GW-3A and GW-3B would reduce the toxicity and volume of the COCs in groundwater at Parcel B through *in situ* groundwater treatment. The risk of potential mobility would be addressed through proper design and implementation of the treatment system and of a groundwater monitoring program. Treatment compounds would be initially injected below the elevation of groundwater contaminants to prevent downward migration of contaminants. Monitoring would continue until the treatment is successful in reducing the concentrations to acceptable levels. The institutional controls would remain in effect to address residual contamination.

The overall rating for Alternatives GW-3A and GW-3B for reduction of toxicity, mobility, or volume through treatment is excellent.

6.3.3.5 *Short-Term Effectiveness: Alternatives GW-3A and GW-3B*

Four factors are considered as part of the short-term effectiveness criterion and are assessed below for Alternative GW-3A and GW-3B.

Under Alternatives GW-3A and GW-3B, the treatment remedy would not present health risks to the community and current occupants because the remedial action is applied as an *in situ* injection, and the treatment additives are not toxic. The risk from groundwater monitoring would be minimal and is less than the long-term monitoring proposed for Alternative GW-2 based on the shorter duration.

Workers applying the treatment would not be exposed to the contaminated groundwater because the remedial action is applied as an *in situ* injection. The risk to workers during groundwater monitoring would be minimized by properly handling groundwater samples and use of appropriate personal protective equipment during sampling. Remediation would be carried out under a health and safety program designed to minimize worker exposure.

Environmental impacts in the areas where the injection treatment would be applied are minor because of the current industrial use of the areas and their distance from the bay. Similarly, the short-term increase in traffic during active treatment and monitoring would have minimal environmental impact.

Active treatment under Alternatives GW-3A and GW-3B would likely be implemented in less than 1 year. Although the reduced groundwater monitoring would be less than 30 years, the duration must demonstrate the effectiveness of the treatment and the permanent reduction of COCs and potential COCs in the groundwater. As with Alternative GW-2, monitoring would occur for short periods with long intervals of inactivity.

The overall rating for Alternatives GW-3A and GW-3B for short-term effectiveness is very good.

6.3.3.6 *Implementability: Alternatives GW-3A and GW-3B*

Implementability includes technical and administrative feasibility and the availability of required resources. Two pilot studies demonstrated that injection treatment is feasible at HPS (Shaw Environmental, Inc. 2005; Tetra Tech 2003b). Treatment requires a moderate level of resources for a short duration. The major difficulty with implementing injection technologies during pilot studies at HPS has been mass transfer of the treatment substrate to the contaminants. Data from pilot studies as well as the lithology of the treatment area would be used to select sufficient injection points for treatment additives to optimize the success of the injection.

Groundwater monitoring is a routine activity and requires a moderate level of resources, but would be less than are needed for Alternative GW-2 based on the shorter duration of the required monitoring.

The overall rating for Alternatives GW-3A and GW-3B for implementability is very good.

6.3.3.7 Cost: Alternatives GW-3A and GW-3B

The total capital and O&M costs for Alternatives GW-3A and GW-3B are presented in Table 6-1 and are detailed in Appendix D. The costs to implement the institutional controls are low, and the cost to implement the monitoring program is moderate. The costs for *in situ* treatment are moderate for Alternative GW-3A and higher for Alternative GW-3B.

The costs for implementing the *in situ* treatments for Alternatives GW-3A and GW-3B were derived from the HPS ZVI pilot study (Alternative GW-3B) and vendor information for substrates for biodegradation of VOCs (Alternative GW-3A) (see Appendix D). The difference between Alternative GW-3A to apply the VOC treatment compounds compared with Alternative GW-3B to apply the ZVI additive is the cost of the additives. Costs for treatment of metals are not included because it is anticipated that (1) the mercury source removal will mitigate mercury concentrations in groundwater, and (2) concentrations of copper and lead in samples collected during the RD will not exceed the trigger levels developed for Parcel B groundwater wells. The overall rating for Alternatives GW-3A and GW-3B for cost of implementing is good.

6.3.3.8 Overall Rating: Alternatives GW-3A and GW-3B

Alternatives GW-3A and GW-3B meet ARARs and protect human health and the environment through active treatment as well as institutional controls. The environment is further protected with a monitoring program that includes sentry wells to assess migration of groundwater to San Francisco Bay. These alternatives are easily implemented with minimal impact to the community. Additionally, these alternatives effectively reduce the toxicity, mobility, and volume of contaminants through treatment.

The overall estimated rating for Alternatives GW-3A, with its lower cost, is excellent. The overall rating for Alternative GW-3B is very good.

6.3.4 Individual Analysis of Original ROD Groundwater Remediation Alternative

The original ROD remedy for groundwater includes (1) lining of storm drains to prevent infiltration of contaminated groundwater, (2) removing of steam and fuel lines, (3) implementing institutional controls to prevent use of groundwater, and (4) monitoring groundwater for up to 30 years. The following evaluation considers the rating of the remedial action if it were completed according to the cleanup goals in the ROD.

6.3.4.1 Overall Protection of Human Health and the Environment: Original ROD Groundwater Alternative

The original ROD alternative would not provide protection to human health and the environment because it would not prevent exposure to VOC vapors that would be expected to accumulate in buildings as the result of vapor intrusion from groundwater. The original ROD alternative did not include institutional controls to limit access to buildings located over VOC plumes. Therefore, the rating for the original ROD groundwater alternative for overall protection of human health and the environment is not protective.

6.3.4.2 Compliance with ARARs: Original ROD Groundwater Alternative

No chemical-specific ARARs are pertinent to the original ROD alternative because no active treatment or removal of groundwater is proposed. The location-specific ARARs identified for activities that would affect San Francisco Bay and the coastal zone at Parcel B would be met. Action-specific ARARs for groundwater monitoring would be met by developing and employing appropriate monitoring protocols. As a result, the original ROD groundwater alternative would meet ARARs.

6.3.4.3 Long-Term Effectiveness and Permanence: Original ROD Groundwater Alternative

The factors evaluated under long-term effectiveness and permanence include the magnitude of residual risks and the adequacy and reliability of controls. Groundwater would be monitored, but not treated, under the original ROD groundwater alternative. Sources such as the VOCs at IR-10 and the mercury at IR-26 would not be addressed. The risk to ecological receptors from COCs in groundwater would not be evaluated or addressed. Institutional controls would not be in place to prevent exposure from vapor intrusion. Overall, the rating for the original ROD groundwater alternative for long-term effectiveness and permanence is poor.

6.3.4.4 Reduction of Toxicity, Mobility, or Volume through Treatment: Original ROD Groundwater Alternative

The original ROD alternative would not reduce the toxicity, mobility, or volume of contamination through active remediation. Therefore, the overall rating for the original ROD groundwater alternative for reducing the toxicity, mobility, or volume through treatment is poor.

6.3.4.5 Short-Term Effectiveness: Original ROD Groundwater Alternative

Four factors are considered as part of the short-term effectiveness criterion and are assessed below for the original ROD groundwater alternative.

The original ROD groundwater alternative would not present any new risks to the community. Minimal health risks would be posed by the long-term monitoring that would periodically extract and collect small amounts of groundwater for sampling.

No remedial action workers would be exposed to risks because no active remedy to groundwater would be applied. Minimal risk to the workers would be posed during the groundwater monitoring events, but proper personal protective equipment and health and safety protocols would minimize these risks.

No adverse environmental impacts would result from construction and implementation of the original ROD groundwater alternative because no groundwater treatment is proposed. Minimal exposure to groundwater would occur during the long-term groundwater monitoring program.

Long-term monitoring for the original ROD groundwater alternative would likely extend over 30 years, although the field activities for this monitoring occur for short periods with long intervals of inactivity.

Based on this evaluation, the rating for the original ROD groundwater alternative for short-term effectiveness is excellent.

6.3.4.6 Implementability: Original ROD Groundwater Alternative

Implementability includes technical and administrative feasibility and the availability of required resources. No construction or O&M would be required to implement the remaining groundwater monitoring under the original ROD groundwater alternative; therefore, this alternative is technically and administratively feasible. Long-term groundwater monitoring is a routine activity and requires a moderate level of commonly available resources. The overall rating for the original ROD groundwater alternative for implementability is excellent.

6.3.4.7 Cost: Original ROD Groundwater Alternative

The cost of the remedial action for groundwater under the ROD is about $8 million to date (not adjusted to current dollars). Groundwater monitoring costs would continue to be incurred into the future. Cost for full implementation would likely require an additional $2 million for a total of more than $10 million. The rating for the original ROD groundwater alternative for cost is poor.

6.3.4.8 Overall Rating: Original ROD Groundwater Alternative

The overall rating for the original ROD groundwater alternative would be not protective.

6.4 COMPARISON OF GROUNDWATER REMEDIAL ALTERNATIVES

This section compares the four groundwater alternatives developed in the TMSRA and the original groundwater remedy selected in the ROD. The discussion of each evaluation criterion generally proceeds from the alternative that best satisfies the criterion to the one that least satisfies the criterion. Table 6-2 summarizes the ratings for each alternative and shows a comparison of the ratings for each alternative for the two threshold and five balancing NCP evaluation criteria.

6.4.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment is a threshold criterion. Protection is not measured by degree; rather, each alternative is considered either protective or not protective. Alternatives GW-2, GW-3A, and GW-3B are protective. Alternative GW-1 and the original ROD groundwater alternative are not protective. Both Alternatives GW-3A and GW-3B have the highest rating and would be protective of human health and the environment. In addition, Alternatives GW-3A and GW-3B would accelerate the contaminant degradation that would reduce the duration of implementation and potentially allow reducing some institutional controls over time. Alternative GW-2 would also be protective of human health and the environment, but would rely more on institutional controls and provides less certainty. Alternative GW-1 and the original ROD groundwater alternative have the lowest rating because it is not protective of human health and the environment.

6.4.2 Compliance with Applicable or Relevant and Appropriate Requirements

Compliance with ARARs is a threshold evaluation criterion. An alternative must either comply with ARARs or grounds for a waiver must be provided. Alternatives GW-2, GW-3A, GW-3B, and the original ROD groundwater alternative meet ARARs. Alternative GW-1 does not meet ARARs.

6.4.3 Long-Term Effectiveness and Permanence

Alternatives GW-3A and GW-3B would provide the highest level of long-term effectiveness and permanence because VOCs would be degraded. Alternative GW-2 would provide a moderate level of effectiveness and permanence because groundwater plumes would be addressed only through institutional controls and monitoring to assess the potential migration of contaminants. The original ROD groundwater alternative would provide only groundwater monitoring and would not address sources such as the VOCs at IR-10 and the mercury at IR-26. This alternative would therefore be assigned a low rating for long-term effectiveness and permanence. Since no action would be taken under Alternative GW-1, it does not provide a long-term effective or permanent solution to the risks from groundwater present at the site.

6.4.4 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives GW-3A and GW-3B are rated the highest because they both reduce the toxicity and volume of the contaminants by active treatment of the VOC plume. Exposure to these contaminants would also be addressed through institutional controls and groundwater monitoring. Alternatives GW-1, GW-2, and the original ROD groundwater alternative would not reduce the toxicity, mobility, or volume of contaminants in the groundwater through treatment. Alternative GW-2 and the original ROD groundwater alternative would not reduce the toxicity or volume of contaminants through treatment, but would monitor the mobility of the contamination through the long-term groundwater monitoring program.

6.4.5 Short-Term Effectiveness

Alternative GW-1 has an excellent short-term effectiveness rating, as no remedial actions are conducted under this alternative. All of the alternatives scored well in terms of short-term effectiveness according to the criteria. Alternatives GW-3A and GW-3B pose a slightly greater risk through use of active *in situ* treatment compared with Alternative GW-2. Alternatives GW-2, GW-3A, GW-3B, and the original ROD groundwater alternative all pose a very low risk to workers during implementation of the groundwater monitoring program.

6.4.6 Implementability

Alternatives GW-1, GW-2, and the original ROD groundwater alternative have the highest rating and are technically the easiest to implement. Alternative GW-2 and the original ROD groundwater alternative would require more resources to conduct the long-term groundwater monitoring program; however, these resources are readily available. Alternatives GW-3A and GW-3B are more complex to implement because of the injection treatment; however, this treatment is a one-time injection that would reduce the resources required for groundwater monitoring as compared with Alternative GW-2 and the original ROD groundwater alternative. Alternative GW-3A may be easier to implement because the injected substrates are slow-release compounds that continue to degrade COCs over time. Their slow release increases the potential to react with contaminants as they disperse in the aquifer.

6.4.7 Cost

Estimated total capital costs for each alternative, except the original ROD groundwater alternative, are summarized in Table 6-1. Alternative GW-1 is rated the highest because no cost is associated because no actions would be taken. Alternative GW-2 has a moderate cost ($1.8 million), most of which is for the 30 years of long-term monitoring. Alternative GW-3A has a slightly higher cost ($2.4 million). Alternative GW-3B has the highest capital cost because of the cost of the ZVI additive ($2.8 million). The cost for full implementation of the original ROD groundwater alternative would likely require at least an additional $2 million for a total of more than $10 million.

6.4.8 Overall Rating of Groundwater Alternatives

Alternative GW-3A has the highest overall rating. The treatment effectively reduces risks to human health and environment and actively treats COCs in groundwater. Alternative GW-3B ranks well also, but the higher cost makes it less advantageous. Alternative GW-2 is easy to implement and less expensive, but it is not as effective as Alternatives GW-3A and GW-3B. Alternative GW-1 and the original ROD groundwater alternative are not acceptable.

6.5 SUMMARY AND CONCLUSION

This section summarizes the rationale for reevaluating the current remedy based on the updated information about the site and subsequent revisions to the conceptual site model.

6.5.1 Soil

The excavation and off-site disposal remedy selected in the ROD would not be protective in the long term as it was originally envisioned because the conceptual site model that formed the basis for the remedy was incomplete. The discrete release of chemicals, referred to as the spill model, was the basis for the remedial action selected in the ROD. Although this conceptual model worked well at many areas of Parcel B, the significant additional information gained from sampling and excavation during the remedial action indicated that the spill model did not account for all areas where chemical concentrations exceeded cleanup goals and that the conceptual site model needed to be supplemented.

Concentrations of a group of metals, especially arsenic and manganese, consistently exceeded cleanup goals at locations across Parcel B. The widespread distribution of this group of metals in soil at Parcel B (that is, their ubiquitous nature) is related to the occurrence of these metals in the local bedrock that was quarried and used for fill during the expansion of HPS in the 1940s. These metals occur naturally in the Franciscan Formation bedrock and were distributed throughout all of HPS, including Parcel B, as it was built. The resulting distribution of metals concentrations in soil is nearly random across the parcel, and the spill model for release does not apply. The concentrations of metals in the bedrock fill sometimes exceed the cleanup goals in the ROD, and is the primary reason that the "step-out" delineation process was not successful everywhere on Parcel B. Application of the original ROD cleanup goals to the ubiquitous metals would result in excavation of most of the bedrock fill at Parcel B to a depth of 10 feet bgs. Remedial alternatives in the TMSRA take into account the revised conceptual site model and address ubiquitous metals using options such as containment beneath covers and institutional controls.

In addition to identifying the ubiquitous nature of several metals in the bedrock fill, sampling and excavation during the remedial action found that the areas at IR-07 and IR-18 contained fill with a high proportion of demolition debris. The highly nonuniform distribution of chemicals within the debris fill also did not conform to the spill model and, consequently, excavations in this area often greatly exceeded the originally planned extent of the removals. Furthermore, methane was detected in soil gas at a small area of the debris fill at IR-07 and a source of mercury is believed to exist at IR-26. In addition, radiological contamination is present at Parcel B that was not known when the ROD was prepared. The debris fill, methane, mercury, and radiological contamination created additional needs to update the conceptual site model and the TMSRA considers remedial alternatives to address these new conditions.

The updated site information for soil at Parcel B and results from the remedial actions completed at Parcel B indicate the need to reassess remediation alternatives selected in the ROD. The selected remedy is not protective of human health and the environment based on the updated information about the site.

6.5.2 Groundwater

The remedy selected for groundwater in the ROD should be revised based on (1) the large amount of new information available from the more than 7 years of groundwater monitoring data gathered at Parcel B, including the detection of chromium VI, copper, lead, and mercury in groundwater, and (2) changes in the toxicity estimates and exposure assumptions for VOCs used for risk assessment since the ROD was prepared. Concentrations of VOCs in the area of IR-10 were found to be an order of magnitude higher than was known when the ROD was prepared. In addition, VOCs are now considered more toxic via the inhalation pathway than when the ROD was prepared. Consequently, intrusion of VOC vapors into buildings is considered a more significant human health risk than it was previously. In particular, the groundwater remedy in the ROD did not identify the VOC plume at IR-10 as requiring remediation. However, this plume may pose a much greater risk than estimated in the ROD. Finally, the ROD does not contain any active remediation options to address the cleanup of VOCs in groundwater.

The updated site information for groundwater at Parcel B and results from the remedial actions completed at Parcel B indicate the need to reassess remediation alternatives selected in the ROD. The selected remedy is not protective of human health and the environment based on the potential risk from vapor intrusion of VOCs from groundwater.

6.5.3 Shoreline

Potential ecological risk to aquatic receptors along the shoreline of Parcel B was not evaluated in the ROD. The SLERA evaluated risks to aquatic receptors and the TMSRA assesses remediation alternatives to address these risks. The SLERA concluded that a variety of organic and inorganic chemicals in sediment along the shoreline and mercury in groundwater at IR-26 pose a potential unacceptable risk to aquatic receptors. The ROD, therefore, needs to be amended to address potential ecological risks.

6.5.4 Radiological

Radiological contamination was not addressed by the ROD; however, radiological contamination is present at Parcel B. The ROD needs to be amended to memorialize the methods and cleanup goals for radiological contaminants that are being addressed by the basewide radiological removal action. The radiological addendum to the TMSRA evaluates remediation alternatives for the radiological contamination.

6.5.5 Conclusion

The excavation and off-site disposal remedy for soil, as described in the ROD, would not be protective in the long term. Site information that the Navy has gained during the remedial action shows the need to (1) supplement the conceptual model to include the random distribution of ubiquitous metals in soil and account for methane, mercury, radiological contamination, and debris fill areas, (2) evaluate amending the ROD, and (3) evaluate additional remedial actions for soil at Parcel B. This TMSRA evaluates modifications to the remedy for soil in accordance with revisions to the conceptual model to support additional remedial actions that will address remaining risks.

Likewise, the remedy for groundwater selected in the ROD needs to be expanded to account for the increased potential risk from VOCs and mercury and other metals in groundwater and to provide remediation alternatives to address this risk. The TMSRA uses the large amount of new information from groundwater monitoring and treatability studies to evaluate modifications to the remedy for groundwater to support additional remedial actions that will address the remaining risks.

The ROD did not address potential ecological risk to aquatic receptors along the shoreline. The TMSRA estimates risk and evaluates remediation alternatives to address these risks.

Finally, the ROD did not address radiological contamination. The ROD needs to be amended to memorialize the methods and cleanup goals for radiological contaminants that are being addressed by the basewide radiological removal action. The radiological addendum to the TMSRA evaluates remediation alternatives for the radiological contamination.

TABLES

TABLE 6-1: SUMMARY OF COSTS FOR SOIL AND GROUNDWATER ALTERNATIVES
Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

Remedial Alternative	Capital Cost	O&M Cost	Contingency Cost	Total Cost
Soil				
Alternative S-1: No Action	$0	$0	$0	$0
Alternative S-2: Institutional Controls, Maintained Landscaping, and Shoreline Revetment	$3,905,000	$654,000	$912,000	$5,470,000
Alternative S-3: Excavation, Methane and Mercury Source Removal, Disposal, Maintained Landscaping, Institutional Controls, and Shoreline Revetment	$8,242,000	$654,000	$1,779,000	$10,680,000
Alternative S-4: Covers, Methane and Mercury Source Removal, Disposal, Institutional Controls, and Shoreline Revetment	$9,002,000	$916,000	$1,984,000	$11,900,000
Alternative S-5: Excavation, Methane and Mercury Source Removal, Disposal, Covers, SVE, Institutional Controls, and Shoreline Revetment	$9,438,000	$916,000	$2,071,000	$12,420,000
Groundwater				
Alternative GW-1: No Action	$0	$0	$0	$0
Alternative GW-2: Long-Term Monitoring and Institutional Controls	$75,000	$1,389,000	$293,000	$1,760,000
Alternative GW-3A: *In Situ* Groundwater Treatment with Biological Substrate Injection, Reduced Groundwater Monitoring, and Institutional Controls[1]	$148,000[1]	$1,858,000	$401,000	$2,410,000
Alternative GW-3B: *In Situ* Treatment with ZVI Injection, Reduced Groundwater Monitoring, and Institutional Controls[1]	$485,000[1]	$1,842,000	$465,000	$2,790,000

Notes: All costs rounded to the nearest $1,000, except total cost which is rounded to $10,000.

Capital Cost is present worth cost assuming immediate expenditure.

O&M Cost is 30-year present worth cost over a period of 30 years.

Contingency Cost is 20 percent of the sum of the present worth capital cost and the present worth O&M cost.

Total Cost is the sum of the present worth capital cost, the present worth O&M cost, and the contingency cost.

1 The analysis of Alternatives GW-3A and GW-3B was based on a general *in situ* injection treatment. Costs for implementing the two types of injection treatments are essentially identical for both the alternatives accept for the cost of the injection materials: bioremediation substrate for Alternative GW-3A, and ZVI for Alternative GW-3B.

O&M Operation and maintenance
SVE Soil vapor extraction
ZVI Zero-valent iron

TABLE 6-2: RANKING OF REMEDIAL ALTERNATIVES FOR SOIL AND GROUNDWATER

Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California

	Overall Protection of Human Heath and the Environment[a]	Compliance with ARARs[a]	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost ($ Million)	Overall Rank by Alternative
SOIL ALTERNATIVES								
Alternative S-1: No Action	Not Protective	Not Applicable	○	◔	◕	●	0	○
Alternative S-2: Institutional Controls, Maintained Landscaping, and Shoreline Revetment	Protective	Meets ARARs	◑	◔	◑	◕	5.5	◑
Alternative S-3: Excavation, Methane and Mercury Source Removal, Disposal, Maintained Landscaping, Institutional Controls, and Shoreline Revetment	Protective	Meets ARARs	◕	◔	◑	◕	10.7	◑
Alternative S-4: Covers, Methane and Mercury Source Removal, Disposal, Institutional Controls, and Shoreline Revetment	Protective	Meets ARARs	◕	◔	◕	◕	11.9	◕
Alternative S-5: Excavation, Methane and Mercury Source Removal, Disposal, Covers, SVE, Institutional Controls, and Shoreline Revetment	Protective	Meets ARARs	●	◑	◕	◕	12.4	●
Original ROD: Excavation, Disposal, and Institutional Controls	Not Protective	Does Not Meet ARARs	◔	◔	◔	◔	>60	○
GROUNDWATER ALTERNATIVES								
Alternative GW-1: No Action	Not Protective	Not Applicable	◔	◔	◕	●	0	○
Alternative GW-2: Long-Term Monitoring of Groundwater and Institutional Controls	Protective	Meets ARARs	◑	◔	●	●	1.8	◑
Alternative GW-3A: *In Situ* Groundwater Treatment with Biological Substrate Injection, Reduced Groundwater Monitoring, and Institutional Controls	Protective	Meets ARARs	●	●	◕	◕	2.4	●
Alternative GW-3B: *In Situ* Treatment with ZVI Injection, Reduced Groundwater Monitoring, and Institutional Controls	Protective	Meets ARARs	◕	●	◕	◕	2.8	◕
Original ROD: Line Storm Drains, Remove Steam and Fuel Lines, Institutional Controls, and Groundwater Monitoring	Not Protective	Meets ARARs	◔	◔	●	●	>2	○

Legend:

- ○ Not acceptable
- ◔ Poor
- ◑ Good
- ◕ Very Good
- ● Excellent

Notes:

a	Overall protection of human health and the environment and compliance with ARARs are threshold criteria and alternatives are judged as either meeting or not meeting the criteria.
ARAR	Applicable or relevant and appropriate requirement
SVE	Soil vapor extraction
ZVI	Zero-valent iron

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PUBLIC SUMMARY

Public Summary: **Parcel B Technical Memorandum in Support of a Record of Decision Amendment, Hunters Point Shipyard, San Francisco, California, December 12, 2007**

The U.S. Department of Navy has prepared this technical memorandum in support of a record of decision (ROD) amendment to address remaining contamination in soil and groundwater at Parcel B at Hunters Point Shipyard. Parcel B has completed the cleanup steps through the ROD, remedial action, and post-construction reporting; however, the updated information about the site that became available during the remedial action indicates that modifications to the selected soil and groundwater remedies are needed to ensure long-term protectiveness. The overall objective of this report is to provide information to support a future proposed plan and ROD amendment that will align the final remedy for Parcel B with its planned reuse and address the recommendations summarized in the first five-year review of remedial actions. This draft final technical memorandum includes (1) updated data, (2) a revised human health risk assessment, (3) a screening-level ecological risk assessment, and (4) a reevaluation of remedial alternatives based on these updates.

The Navy considered the following remedial alternatives for contaminants in soil at Parcel B: (1) no action; (2) institutional controls (IC), maintained landscaping, and a shoreline revetment; (3) excavation, methane and mercury source removal, disposal, ICs, maintained landscaping, and a shoreline revetment; (4) covers, methane and mercury source removal, ICs, and a shoreline revetment; and (5) excavation, methane and mercury source removal, disposal, covers, soil vapor extraction, ICs, and a shoreline revetment. The Navy considered the following remedial alternatives for contaminants in groundwater at Parcel B: (1) no action; (2) long-term monitoring of groundwater and ICs; and (3) *in situ* treatment, groundwater monitoring, and ICs.

Information Repositories: A complete copy of the "Final Parcel B Technical Memorandum in Support of a Record of Decision Amendment," dated December 2007, is available to community members at:

San Francisco Main Library
100 Larkin Street
Government Information Center, 5th Floor
San Francisco, CA 94102
Phone: (415) 557-4500

Anna E. Waden Bayview Library
5075 Third Street
San Francisco, CA 94124
Phone: (415) 715-4100

The report is also available to community members on request to the U.S. Department of the Navy. For more information about environmental investigation and cleanup at Hunters Point Shipyard, contact Darren Knight, remedial project manager for the Navy, at:

Darren Knight
Department of the Navy
Base Realignment and Closure
Program Management Office West
1455 Frazee Road, Suite 900
San Diego, CA 92108-4310
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Fax: (619) 532-0995
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ATTACHMENTS 1 & 2

Attachment 1

NAVY
PRINCIPLES AND PROCEDURES FOR SPECIFYING, MONITORING AND ENFORCEMENT OF LAND USE CONTROLS AND OTHER POST-ROD ACTIONS

PREAMBLE

Since the Department of Defense (DoD) /Environmental Protection Agency (EPA) Model Interagency Agreement (IAG)/Federal Facility Agreement (FFA) was developed in 1988, EPA and Navy have gained considerable knowledge and understanding about post-Records of Decisions (ROD) activities, especially Land Use Controls (LUCs). Thinking, policies, regulations and procedures concerning LUCs have evolved considerably since DoD and EPA developed the 1988 FFA model language. New statutes and regulations related to LUCs are being considered in many states. Accordingly, EPA and the Department of the Navy (DON) believe that a set of Principles will assist Navy field commands and EPA Regions to better implement our respective Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) responsibilities. The Principles described below do not replace or substitute for any existing CERCLA statutory or regulatory requirement. Rather they provide a mutually agreeable framework to provide a more efficient process to implement LUCs at National Priority List (NPL) installations.

These Principles will guide the EPA and DON personnel involved in these decisions. They are written in full knowledge that state regulatory and trustee organizations have independent responsibilities and authorities. EPA and the DON recognize the importance of the state role in helping to ensure a cleanup is protective of human health and the environment. Headquarters EPA and DoD will jointly develop a communications plan to ensure we include the states in this important issue.

These Principles support the President's Management Agenda by focusing on improving environmental results. The Principles encourage continued innovation and improvement in CERCLA implementation. EPA and the Components should continue to propose and pilot initiatives at Component installations or at other properties for which they are responsible. This includes proposing variations in, or alternatives such as performance-based practices to, the approach described in this document.

PRINCIPLES

- At sites where remedial action is determined necessary to protect human health and the environment, the actions must be documented in accordance with CERCLA and its implementing regulation, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

- At sites where contaminants are left in place at levels that do not allow for unrestricted use, LUCs are used to ensure that the contaminants do not pose an unacceptable risk to human health or the environment. LUCs consist of engineering controls and/or institutional controls.

- The EPA and DON desire to ensure that LUCs are specified, implemented, monitored, reported on, and enforced in an efficient, cost-effective manner that ensures long-term protectiveness. In addition, in accordance with CERCLA and the NCP, if an equally protective but more cost-effective remedy is identified, DON may propose, and EPA will consider, using the more cost-effective remedy.

- The EPA acknowledges the DON's role and responsibilities as the Federal Lead Agent for response actions. This role includes selecting remedies with EPA at NPL sites and funding response actions.

- The DON acknowledges EPA's role and responsibilities for regulatory oversight and enforcement at NPL sites. This role includes ultimate ability to select the remedy at NPL sites if EPA disagrees with DON's proposed remedy and dispute resolution fails.

- Federal Facilities Agreements (FFAs) are CERCLA 120 agreements used by DON and EPA to describe in detail the roles and relationships among DON, EPA and often the state. They form the foundation for these relationships regarding DON's response actions at NPL sites. FFAs also contain installation specific details and procedures for planning, budgeting, and dispute resolution. DON and EPA desire FFAs to be as standardized as possible and relatively <u>static</u> (i.e., the FFA should not need to be changed for a given installation).

- Primary Documents developed under the FFA are relatively <u>d</u>ynamic and document important plans and actions. In that sense, they are action-oriented. For example, a Site Management Plan is revised yearly via collaboration among DON and EPA remedial project managers and is an important tool for planning response actions and demonstrating commitment to the public. Likewise, a LUC Remedial Design (RD) or Remedial Action Work Plan (RAWP) describes those actions that are needed to ensure viability of both long-term engineered and institutional control remedies.

- Records of Decision should document the remedy selection process and remedy decision in accordance with CERCLA and the NCP, as well as applicable and appropriate guidance, regulations, standards, criteria, and policy. With regard to LUCs, the ROD should describe the LUC objectives; explain why and for what purpose the LUCs are necessary, where they will be necessary, and the entities responsible for implementing, monitoring, reporting on and enforcing the LUCs. The ROD will refer to the RD or RAWP for implementation actions.

- Where situations arise (such as new cleanup standards; new or additional contamination is discovered on a site, etc.) that require additional response actions that go beyond the actions and objectives described in a ROD, and any related ROD Amendment or Explanation of Significant Difference (ESD), the additional actions required and their remedial objectives will be further documented in an ESD or ROD Amendment, as appropriate. There may also arise situations after a remedy has been completed that require removal actions to protect human health and the environment, such as the newly discovered contamination posing an imminent risk to human health. In such circumstances, documentation as required in the removal process should be created.

- Given the above, EPA and DON agree that the most efficient framework for specifying, implementing, monitoring, reporting on and enforcing LUCs is:
  - a standard FFA for NPL sites,
  - a clear, concise RoD with LUC objectives, and
  - a RD or RAWP with LUC implementation actions.

Note: These documents are described more fully below.

- EPA and DON will move expeditiously to finalize all outstanding FFAs using a standard FFA template as a guide to minimize the development/writing process.

Note: A "standard FFA" means the Agreement presently being used between EPA and DoD using the DoD-EPA model language, plus site-specific statements of fact, plus the additional primary document shown in Attachment (1).

- EPA and DoD will initiate a task force with appropriate headquarters and field representatives from EPA and the military services. The task force will make recommendations as to how to ensure that the same documentation can be used to memorialize both remedial action completion and deletion, as well as to determine the process whereby DoD and EPA will document the completion of the remedial actions required by the ROD in a single primary document. The task force will examine ways to reduce document size, review time, and revisions. The task force will recommend changes to guidance and policy that will help reduce document size or streamline the process in order to manage costs. The task force may also include other stakeholders.

  After reviewing the task force recommendations EPA and DoD will determine how to ensure that the same documentation can be used to memorialize both remedial action completion and deletion, as well as to determine the process whereby DoD and EPA will document the completion of the remedial actions required by the ROD in a single primary document. In addition, EPA and DoD will streamline the remedial process and better manage costs. While the efforts of the Task Force are meant to complement the Principles described above, its work is separate from the Principles and must not impede their implementation. The work of the Task Force also must not impede completion or closeout of individual sites or operable units.

GENERAL PROCEDURES

1. Federal Facility Agreement

- The LUC implementation and operation/maintenance actions will be included in the RD or RAWP which are already primary documents deliverable under standard FFAs. In addition, the same documentation as determined by the task force and approved by the Parties to memorialize both the remedial action completion and deletion will be provided as a primary document for new FFAs. For existing FFAs without such a primary document, this document will be provided as an attachment to the RD or RAWP with the same enforceability as a primary document.

Note: Model FFA language will need to be supplemented to reflect these Principles and Procedures. Attachment (1) contains necessary modifications to FFA language.

2. Record of Decision

- It is EPA's and DON's intent that Records of Decision (RoDs) continue to be consistent with CERCLA and the National Contingency Plan. Relative to land use controls and institutional controls, the ROD shall:
  - Describe the risk(s) necessitating the remedy including LUCs;
  - Document risk exposure assumptions and reasonably anticipated land uses;
  - Generally describe the LUC, the logic for its selection and any related deed restrictions/notifications;
  - State the *LUC performance objectives*. (See attachment (2) for examples of LUC performance objectives);
  - List the parties responsible for implementing, monitoring, reporting on, and enforcement of the LUC;
  - Provide a description of the area/property covered by the LUC (should include a map);
  - Provide the expected duration of the LUCs; and
  - Refer to the RD or RAWP for LUC *implementation actions*, since these details may need to be adjusted periodically based on site conditions and other factors. (See attachment (2) for examples of LUC implementation actions).

- The ROD at transferring properties will need to be crafted based on the responsibilities of the new owner and state-specific laws and regulations regarding LUCs. At transferring properties, compliance with the LUC performance objectives may involve actions by the subsequent owners in accordance with deed restrictions, however, ultimate responsibility for assuring that the objectives are met remains with DON as the party responsible under CERCLA for the remedy. DON and regulators will consult to determine appropriate enforcement actions should there be a failure of a LUC objective at a transferred property.

3. LUC Remedial Design (RD) or Remedial Action Work Plan (RAWP)

- The RD or RAWP will be provided as a primary document in accordance with the FFA.
- The RD or RAWP will describe short and long-term implementation actions and responsibilities for the actions in order to ensure long-term viability of the remedy which may include both LUCs (e.g., institutional controls) and an engineered portion (e.g., landfill caps, treatment systems) of the remedy. The term "implementation actions" includes all actions to implement, operate, maintain, and enforce the remedy. Depending on the LUC and site conditions, these actions can include:

- Conducting CERCLA five-year remedy reviews for the engineered remedies and/or LUCs.
- Conducting periodic monitoring or visual inspections of LUCs; frequency to be determined by site-specific conditions.
- Reporting inspection results.
- Notifying regulators prior to any changes in the risk, remedy or land use including any LUC failures with proposed corrective action.
- Including a map of the site where LUCs are to be implemented.

For active bases,

- Developing internal-DON policies and procedures with respect to LUC monitoring, reporting, and enforcement in order to institutionalize LUC management and to ensure base personnel are aware of restrictions and precautions that should be taken; Consulting with EPA at least 14 days prior to making any changes to these policies and procedures to ensure that any substantive changes maintain a remedy that is protective of human health and the environment.
- Developing a comprehensive list of LUCs with associated boundaries and expected durations.
- Notifying regulators of planned property conveyance, including federal-to-federal transfers. "Property conveyance" includes conveying leaseholds, easements and other partial interests in real property.
- Obtaining regulator concurrence before modifying or terminating land use control objectives or implementation actions.

For closing bases/excess property:

- Notifying regulators of planned property conveyance, including federal-to-federal transfers.
- Consulting with EPA on the appropriate wording for land use restrictions and providing a copy of the wording from the executed deed.
- Defining responsibilities of the DON, the new property owner and state/local government agencies with respect to LUC implementation, monitoring, reporting, and enforcement.
- Providing a comprehensive list of LUCs with associated boundaries and expected durations.
- Obtaining regulator concurrence before modifying or terminating land use control objectives or implementation actions.

Note: The mix of responsibilities among DON, the new property owner, and other government agencies depends on state and federal laws and regulations *that are applied in the state. Implementation actions at closing bases may include elements characteristic of both active and closing bases, depending on the timing of transfer.*

- Should there be a failure to complete LUC implementation actions at an active base, the EPA Region shall notify the installation and seek immediate action. Should there be a failure to complete LUC actions after such notification to the base, EPA may notify the Deputy Assistant Secretary of the Navy (Environment) who will ensure that LUC actions are taken.

- Should there be a failure to complete implementation actions that are the responsibility of a subsequent owner or third party at a transferred property, EPA and DON will consult on the appropriate enforcement action. Should there be a failure to complete implementation actions that are the remaining responsibility of DON at a transferred property, the EPA Region will notify the cognizant Navy Engineering Field Division. If necessary, EPA may notify the Deputy Assistant Secretary of the Navy (Environment) who will ensure that corrective action is taken.

  Note: The RD or RAWP should contain no more or no less implementation actions than needed to ensure the viability of the remedy. There is a delicate balance required. EPA and DON both desire to ensure protectiveness while minimizing process and documents. The parties agree to work diligently to define the appropriate implementation actions for each LUC. EPA and DON believe the key elements can be easily developed between RPMs in a matter of a few hours. Based on detailed discussions and the examples shown in Attachment (2), EPA and DON expect that the LUC portion of the RDs or RAWPs to be in the range of 2-6 pages. If combined with a sampling plan, there may be additional pages needed to list the analyses, sampling locations and frequencies.

4. LUC Data

- The DON will ensure that all LUCs at its installations are included in the Service LUC database.

Attachments:

1. Incorporating Land Use Control (LUC) Objectives and Implementing Actions into Federal Facilities Agreements (FFAs)
2. Examples of LUC objectives and LUC Implementation Actions

Attachment 1 to Navy Principles

INCORPORATING LAND USE CONTROL (LUC) OBJECTIVES AND IMPLEMENTATION ACTIONS INTO FEDERAL FACILITIES AGREEMENTS (FFAs)

FFA Model Template Additions/Changes

1. Definitions Section:

Add: "Land use controls" shall mean any restriction or administrative action, including engineering and institutional controls, arising from the need to reduce risk to human health and the environment.

2. Primary Documents:

Add: A document memorializing remedial action completion.

Note: EPA and DoD believe it is important that a primary document: (1) document the completion of remedy-in-place and/or site close-out and (2) receive concurrence from EPA. The task force discussed above will make recommendations on the scope and content of the document, and DoD and EPA will determine this document after reviewing the task force recommendations. In the meantime, EPA and DON shall enter into FFAs which include a primary document memorializing remedy completion. The document shall not duplicate information in the Administrative Record or previously provided to EPA. Previously provided information shall be referenced and itemized. New information/data (e.g., sampling data) may be needed to demonstrate that the Remedial Action Objectives have been met. The report shall also include any as-built drawings for remedies if different from the remedial design. EPA and DoD do not envision this to be a lengthy document, but shall contain only the information needed to justify the remedy completion. EPA and DoD believe the document should discuss how the remedial objectives in the ROD have been met. It should not be used to expand the scope of requirements beyond the remedial actions required in the original ROD or any subsequent amendment or explanation of significant difference. Instead, if new requirements are needed for a protective remedy, these will be documented in an Explanation of Significant Difference or ROD Amendment, as appropriate, prior to *reaching the milestone. The EPA and DoD will determine the precise nature of this document after reviewing the task force's recommendations.*

Change: Eliminate the sub-bullets (subsidiary documents) under remedial action work plan for document streamlining purposes.

EXAMPLES OF LUC OBJECTIVES AND LUC IMPLEMENTATION ACTIONS

(Note: Actions are to be tailored to site-specific conditions.
This is neither a mandatory nor a complete list)

LUC OBJECTIVES (contained in ROD)

- Ensure no construction on, excavation of, or breaching of the landfill cap.
- Ensure no residential use or residential development of the property.
- Ensure no withdrawal and/or use of groundwater.
- Ensure no excavation of soils without a use permit and special handling procedures.

***LUC IMPLEMENTATION ACTIONS** (contained in the RD or RAWP)*

- Conduct a CERCLA five-year remedy review of the LUC and provide to EPA for review.
- Conduct annual inspections of the LUC and report results (active or BRAC – responsible party to be defined).
- Record the LUC in the base master plan. (active)
- Produce a survey plat of the LUC by a state registered land surveyor. (active or BRAC).
- File the survey plat with the local government/Circuit Court for purposes of public notification (active or BRAC)
- Place a survey plat in CERCLA administrative record, and send copies to EPA and state. (active or BRAC).
- Develop and implement a base procedure that requires excavation to be approved by the Public Works Officer or equivalent official. (active)
- Develop and implement a base procedure that requires changes in land use to be approved by the Public Works Officer or equivalent official. (active)
- Notify the regulatory agencies 45 days in advance of any Base proposals for a major land use change at a site inconsistent with the use restrictions and exposure assumptions described in the RoD, any anticipated action that may disrupt the effectiveness of the land use controls, any action that might alter or negate the need for the land use controls, or any anticipated transfer of the property subject to the land use controls.
- Obtain regulator concurrence before modifying or terminating land use control objectives or implementation actions.
- Maintain a comprehensive list of LUCs with associated boundaries and expected durations.

Note: These examples are consistent with draft EPA guidance: "Describing

Institutional Controls in Remedy Decision Documents at Active Federal Facilities".